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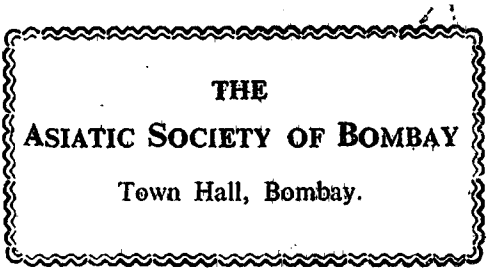

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R. C. 42

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REPORTS

ON THE

VIENNA UNIVERSAL EXHIBITION

OF

1873.

PART II.

R. C. 42

Presented to both Houses of Parliament by Command of Her Majesty.

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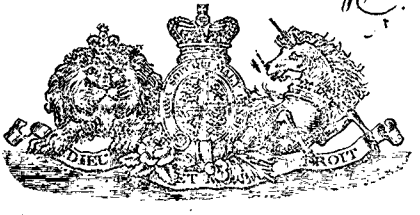

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1874.

[—1072.—I.] *Price 7s. 6d.*

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WORKMEN'S COTTAGES.

DR. ANDERSON.

MACHINE TOOLS, TEXTILE AND OTHER MACHINERY.

Report on [illegible]E Tools, Textile, and Other Machinery. (Group XIII.) By J. Anderson, Esq., C.E., LL.D., &c.

The Universal Exhibition held at Vienna in 1873 contained the greatest display of art that has yet been made in any part of the world, and was rendered doubly interesting from the admirable manner in which it was carried out; the organisation, as a whole, reflected the utmost credit upon the Austrian authorities, as well as on the foreign commissioners of the various countries who were concerned in their respective departments, and upon none more than the British. Their arrangements were most successfully conducted throughout, and apparently to the entire satisfaction both of exhibitors and jurors. After going over that grand collection the first impression produced in the mind of the visitor, when able to realise the vastness of the Exposition, was a feeling of intense pride, that the human race has the energy and the brain power to be capable of producing such a variety of wonderful things; and the second impression was, that there is not so much room for any one nation in particular to exult over another, as is frequently supposed to be the case; the knowledge of practical art and science is extending rapidly in every direction, and more especially in regard to machinery construction, showing us that there are heads to plan and hands to work with refined skill spread over the larger part of the earth's surface, and that very shortly engineering will be as widely disseminated as carpentry has been in past ages. The balance of competition will depend more on local circumstances than upon any special fitness of one set of men as compared with another, for the human mind seems peculiarly fitted from its inherent character to adapt itself readily to constructive art, and this, combined with the self-evident advantage to be derived from the aid of machinery, will be found a sufficient stimulus to extend its application still farther, helping onwards the rising tide of civilisation, and ameliorating the condition of mankind generally.

It is a difficult task to attempt to concentrate into a short report such a picture of the machinery there submitted for competitive examination as would be in any respect satisfactory, because the mere enumeration of the exhibitors' names would more than occupy the entire space, and to give such a description of the good machinery at the Vienna

Exhibition as would convey to those who have not examined it any correct idea of the ingenious detail of that grand collection, would need a large volume. Were a ready made compilation admissible, then a reprint of the illustrated catalogues which were so freely distributed by the chief exhibitors, would, with the addition of a few explanatory remarks in order to make intelligible some of the more complicated machines, enable a stranger to form a very good approximate estimate of the display that was made, and such a compilation, written systematically, would resemble the kind of report which is desirable, in order to preserve an accurate record of the contents of the Exhibition; still, such a report would only be approximate, because in the greater number of the catalogues the illustrations were merely pictures or photographs, rather than copies of the ordinary machine drawings best calculated to assist the class of readers for whom this report is intended. From the circumstance that many of the leading types of the more important classes of machines to be reported upon have been already illustrated in the literature devoted to this subject (chiefly written for the benefit of those who are more than ordinarily interested in having precise knowledge), the want of fulness in the description given in the following pages will not be felt to the same extent as it would otherwise have been, but be that as it may, the limited space which is allotted to this report altogether precludes the attempt of making even a few remarks on many of the most noteworthy specimens of ingenuity, because they have to be reckoned by thousands. All, therefore, that can now be attempted will be to draw the general lessons which were conveyed and taught by the Exhibition, chiefly with a view to the furtherance of our own improvement as a machine-making nation.

In the British report on the Paris Exhibition of 1867, some criticisms were made upon the more glaring defects in machine tools which were there observable; it is gratifying to find that in the collection at Vienna, the objects sought by those criticisms were in a great measure gained, inasmuch as but few, if any, of the machines in the British department had those faults that were so pointedly referred to in that report, and whatever may be the explanation, it was likewise rare to find them in the products of other nations. The improving effect of such exhibitions is strikingly shown by these changes, arising from so many intelligent and eager competitors being thus brought together. This sharpens the intellect and leads to discussion, and the good

influence which may be derived from such meetings is gradually spread over the machine-making world for the general benefit of mankind.

A similar course will be pursued in this report as opportunity offers, with the hope that it may tend to the elimination of whatever may be deemed prejudicial to the advancement of our own machinery in future competitions.

In a report of this nature it may simplify matters to look at all the things to be referred to as mere tools to perform some purpose, that a hammer is merely a tool to give a blow, whether worked by hand, by water, or by steam; the first hammer may have been a stone or a wooden club, but as necessity arose, change after change was introduced until hammers have at length reached their present condition; the same with all other tools, the intricate machine grows out of the simple implement, like the complex wool-spinning machine of modern times out of the distaff and spindle, the development depending on the circumstances.

The human race finds itself located on the crust of a little world surrounded with a great variety of materials either in the earth or growing upon its surface, and being observing, ingenious, and industrious, man has gradually endeavoured to apply them severally to his own purposes. Soon discovering that the human hand unaided made but slow progress, he has been in past ages, and more so at the present time, is, continually devising expedients of all kinds to assist his efforts; and these devices may be said to constitute the class of articles that are herein-after referred to, some of them simple and to be used in conjunction with his own labour, others more complex, to be worked by other forces of nature, but all having the same object in view.

The various machines mentioned in this report are all of the tool character in one sense, although for convenience they are generally subdivided; yet the word "tool" may include all sorts of machines or implements that deal with materials in order to turn, twist, or work them to man's purposes, whether actuated by manual labour or by any other power, and it is frequently found next to impossible to draw the line where the simple tool may be said to end and pass into the more complex machine. It is now conventional to apply the term "machine tools" to some of the said appliances, for instance, to lathes and other apparatus for dealing with metal and wood, while more complicated tools such as those for working cotton, flax, wool, or such other materials have acquired the name of "textile machinery," and there are many varieties of other tools, such

for example as those for making bricks by steam or other than manual power, that are usually called "machines," and although such nomenclature is merely a matter of convenience, still it must be conformed to on account of the advantage which the arrangement offers.

In the general machinery of Group XIII. there was comprised the extensive class of apparatus commonly termed "machine tools," likewise the machinery of the textile manufactures, and a still more extensive variety of other machines which are employed in changing the condition or form of almost every kind of material, too numerous to be named, and which it is unnecessary to classify in a report that is not systematic. Machine tools generally, including those other machines that are employed in operating upon the various classes of substances for which machinery has been applied, but exclusive of the class of machinery for textile manufactures, were a very prominent feature in the Vienna Exhibition; indeed, the number of such machines as were there exhibited by most of the leading manufacturing countries of the world was enormous, and as a general rule was so good that it was not difficult for even the superficial observer to perceive that our relative position as a nation with other nations in regard to these productions is altering at each successive universal gathering.

In the official report upon this class of machinery in the Paris Exhibition of 1867, especially of the machine tool section, much regret was expressed in regard to our shortcomings in the quantity displayed as compared with our relative appearance in 1862 and 1855, but more especially in 1851 when we were unrivalled in every respect, and were by general consent considered above comparison with the rest of the world. A similar regret has now to be expressed, because many of our best houses were not represented at Vienna by even so much as a single specimen: hence the general poverty. Every house of high standing might surely have afforded to send one sample of its best products, if only from a patriotic motive. The truth must be told that on this occasion England was not in some branches properly supported by her sons, and even Scotland, who prides herself in not requiring to be reminded of her duty, was most miserably represented, and was even relatively in a much worse position than England.

It will be remembered that, in Paris in 1867, France made a very grand display, as also did Germany, but on the present occasion the latter country has come out in such

tremendous [illegible] we, as a nation, may well ponder over the [illegible] waits us if we are lethargic and neglect such a [illegible] portunity as that afforded at Vienna. Our machine-making position in the world is not to be maintained by hiding our light under a bushel; it has to be made known to the rest of mankind, and although it may offend our pride to be told that we are being outstripped in the race, still such will be the case if we are not prepared to make more strenuous exertions in the future either as individuals, or collectively at the public expense. A most conspicuous exception, however, to the general shortcoming was in the magnificent display of agricultural machinery by nearly all our leading houses; the mechanism of every sort was almost all of the highest excellence and went far to redeem our character in other branches, and to place us as agricultural engineers in the front rank, with the general concurrence of all; nor was there anything particular to complain of in regard to the textile machinery except scarcity, the simple fact that Platt Brothers of Oldham were present, and along with them Lawson and Sons of Leeds, and Combe and Barbour of Belfast, all of whom received a diploma of honour, gave abundant evidence that there is yet life and energy in the old country. It would have been the same with the other machine branches if the first-class houses of the nation had come forward with their best specimens, for although to some of our foreign competitors we may appear to be going backwards, still, it is not really so except in the relative sparseness of our productions at such gatherings. We are still an inventive and hard-working nation, and if we pull together and are determined not to be beaten, shall be quite able, even in appearance as well as in reality, to hold our own.

The gratitude of the nation is largely due to many exhibitors, who entirely from a sense of duty incurred immense trouble and expense, far beyond any prospective pecuniary recompense, and well do they deserve their share of the meed of approbation which they have earned for the nation. The British exhibitors were placed at a disadvantage, because they did not have the public Exchequer to aid them in the same manner as the exhibitors of most of the other nations. Under such circumstances it has to be remembered that, notwithstanding our apparent barrenness, yet the noble patriotism shown by a great number of Britons on this occasion was not excelled by the exhibitors of any nationality, and is more precious than any jewel to be found in the Vienna Exhibition.

The most important lesson to be derived from an examination of the display made at Vienna was with reference to our own deficiency, for notwithstanding the high proportion of diplomas of honour and other medals that were awarded to our exhibitors, yet it must be confessed that this country did not come forward as it might have done. It was only when too late, and after seeing what the rest of the world has done, that much regret was expressed, and all felt that England cannot afford to hang back at these international competitions. The conviction of our people was almost unanimous, that this country to retain her proper place must put forth all her energy and skill, and give the utmost publicity attainable as a matter of justice on behalf of our enterprising population, in order to maintain her present scientific pre-eminence amongst the strongly competing nations with which she has now to contend. This, therefore, is the great question for the nation to consider. No doubt there were cases where, through the illness of the head of the firm or other cogent reasons, it was found impossible to undertake the labour of an Exhibition. These, however, were the exceptions, and only afford a negative explanation of a very serious difficulty. This point must be insisted upon with all the earnestness that can be brought to bear upon the subject. It would be useless attempting to answer the excuses which have been made in order to account for the absence of so many, for whether due to lethargy or indifference, or on account of the expense, it tells against us as a people. There may be some who do not see the force of the patriotic obligation, and who have come to think that the high position to which they have attained is entirely due to themselves as individuals; but such is not strictly the case: much of the success has been derived from the natural resources and facilities of England and a well-trained population, and from the co-operation of all concerned in the immediate production of the various articles: hence, on these grounds, we should in some measure consider ourselves more as stewards with duties as well as rights, and scarcely at liberty, as rightly understood, to do as we please with what may conventionally be called our own. This is an important matter for future consideration as it most seriously affects our vital interests, and a proper understanding of this question should be arrived at before another Exhibition comes round.

It was impossible for a juror to spend six weeks in the Exhibition without perceiving that there existed a slight feeling of rivalry amongst ourselves instead of the

determination to make a grand and combined effort to form a formidable phalanx in the presence of our competitors; the principle of "every man for himself" will not stand the test to which we are put; in such an Exhibition we must in some degree revert to the good old maxim of "each "for all, and all for each," as was done at Vienna by the English makers of agricultural engines, and to a great extent by the American Exhibitors in regard to their general display. The primary effort should be for the welfare and honour of the country, and, secondarily, for the individual honour, because the disgrace arising from any of our imperfections falls upon the nation entirely, at least so far as the opinion of the rest of the world is concerned, whereas the blame to an individual is soon forgotten.

Although the British machinery occupied a much greater space than was required by the American display, yet, taken as a whole, there was not (whatever may be the explanation), a proportionate amount of new ideas brought forward. The trade disputes of late years must have had a prejudicial and withering effect upon the minds of men who have the thinking part of the duty to perform, and the tendency of such disturbing influences is to dry up the spring from which invention flows. The class of machine tools that are employed in working wood was the most conspicuous exhibit in the British section, both for extent and variety. In this branch of machinery we came out nearly in full strength, and, what was more to the point, our exhibitors were not afraid to work their machines. The British modern wood machinery may be said to be almost entirely the work of the past twenty years. The few remains of the wood machinery which previously existed are now absorbed in the more modern tools by the gradual development of the principle of natural selection. Many of the ideas of Bentham, Brunel, and Bramah have been made available and incorporated with new ideas, and some of the older notions have been dropped, being now unnecessary. In 1851 we were taken by surprise with a few simple machines for working wood which came from America, and from them in a great measure was derived the impetus that has pushed this branch up to its present condition. This machinery will be referred to in the proper place, and more in detail if space permits: suffice it to say here, that as a whole it was very good, and equal to the best in the Exhibition, although, perhaps, not so perfect in some minute details as that shown by certain other countries. It was interesting to observe a slight changing of places amongst our leading

houses since 1867 in Paris; some are stationary, one has gone up at least one round of the ladder, while another is scarcely up to the former position, not due to design or arrangement, but to careless workmanship, gear working roughly, parts unbalanced and even out of truth, simply the result of negligence. In the department of machine tools we were very deficient, more especially in regard to quantity put forward, and likewise in originality. To the knowledge of the writer, it need not have been so. There have been more cleverly designed tools and collateral inventions set to work in England since 1867 than there were in the Vienna Exhibition from all countries put together, even including America, which was the most prolific, but scarcely any of them were exhibited, and consequently the nation did not take the full credit for its deserts. The workshops of certain leading firms in England are being filled up with tools of a special kind, possessing great originality with regard to fitness for a purpose in the manufacture of general machinery, agricultural engines, small arms, and a variety of other things, of which scarcely one specimen was sent to Vienna. But in none of the machine tool collections from any country, excepting America, was there to be seen any extensive attempt at such fresh devices, nor did we show any of the new class of ordinary tools that are being introduced by those firms, lathes with four spindles or four slide rests, for example, which the more enterprising houses have in use, lathes that enable one man to turn and cut four screws at one operation. Had we done so, England would certainly have received some additional diplomas.

It is, perhaps, too much to expect that the English houses which are making such manifold tools for their own use only should have stepped out of their way in order to show them at Vienna to their competitors in other articles. Our tool-makers, however, ought to be on the alert to make this and any other class of similar articles for the general use of engineers; for it is only by going in that direction, in devising instruments whereby one man can do the work of four, that we shall be enabled to produce still more economically, and thereby to overcome the disadvantage arising from the high price of labour, fuel, and other materials in combination with a shorter period of working, all which tend to handicap Britain in the race. Every device tending to cheapen production ought to be hailed, not only by manufacturers, but by intelligent workmen as well, because such tools constitute the very agency whereby high wages can be maintained, and that nation which, never standing still,

takes the lead in the perpetual introduction of this class of machinery, will be the most likely to command the outlying markets of the world. At the present time we, as a nation, both in private works and in Government establishments, are doing all this, and yet we did not send our products in new designs; we have preferred to hide our light, and therefore must take the consequences, whether for good or evil. Not only in regard to the class of original machine tools did we come short, but even in the ordinary class, of which we probably make more than any nation, in which deficiency we are, as a country, perfectly without excuse. The unavoidable absence of Sir Joseph Whitworth from the Exhibition was greatly felt in the British department. All engineers are aware how much we are indebted to his refining influence, and the simplicity and beauty of construction which he has introduced. His display at Paris in 1867 helped to cover a multitude of other shortcomings in our machinery display on that occasion, but the necessity for his presence was even more apparent in the present Exhibition than it was in 1867, and many were the regrets expressed that the best position in the building, which he should have occupied, was filled with tools not up to the Whitworth standard, and far from typical of the quality which English tool makers profess to supply.

There were no machine tools from Patricroft: the names of Hulse, Smith and Coventry, and many others were not mentioned in the catalogue, and, but for the display made in textile machinery by the house of Lawson and Son, even Leeds, which is known to be a great centre of manufacture for machine tools of the highest class, would have been almost a blank, and the absence of the leading houses of this town was sorely felt. But the display of machine tools in this Exhibition that was made by the other nations was considerably above the average of that in former exhibitions, and the number and variety exceeded any former precedent, hence our deficiency became all the more apparent, and but for Lancashire would have been still more so. The firm which probably made the most perfect display in the entire group was from Manchester, and although the collection was not a large one, yet to some extent it served to redeem our character.

After a careful survey of the machinery of the entire Exhibition, the impression was left upon the mind of the observer that its great distinguishing feature was not originality, or even novelty. Every country put forward new contrivances, some of them really ingenious, but

still the virtue of originality did not predominate. The most striking general peculiarity was the marked improvement upon the machines that have been shown at former Exhibitions, and the change for the better since 1867 was very perceptible. This change extended to almost every detail, general design, proportion in regard to strength, simplicity of arrangement, and to a partial extent in the selection of proper materials, but more especially in regard to workmanship. The widespread acquaintance with all past invention was apparent, the influence of Science and Art teaching, which is now so general upon the continent, enables the possessor to make the best of the past, but whether it assists in developing new invention to the same extent is more doubtful; the rapid strides which are being made by many nations in the various branches of machine engineering, which were formerly our own specialty, is greatly due to the teaching of the science school, no doubt fostered by the perception of our wealth and greatness, a system the reverse of the workshop education through which our position was attained; our leading men of the past were in a great measure theoretically self-taught, and comparatively few were furnished with the systematically taught scientific education such as is now imparted to the engineering youth of Germany. It will be interesting to watch the effect of the Science and Art teaching upon the inventive power of our own young men in those branches where real practical knowledge is the requirement, in contradistinction to the research necessary in those other branches where changes are discoveries as well as inventions, for instance,—to contrive a steam engine that will reduce the consumption of fuel to half the present expenditure needs a different order of mind and training from that required in the improving of a spinning machine to double its produce. Notwithstanding the exuberance of contrivance and design shown at Vienna, it was more by shuffling the old inventions than in devising new ones. This was perceptible in taking even a cursory look at the machinery of the Exhibition to which this report refers. Any one who knows the past history of such contrivances could not fail to perceive that comparatively few of the things exhibited depend upon the producers for their existence, but that the greater number contain the impress of some other man. In this respect the lines and mark of Richard Roberts were perhaps the most conspicuous, and his name will be impressed for a long time to come upon machine tools and spinning machinery; less easily could be traced an almost infinite

series of workshop tools that have come down to us from Wilkinson and Murdoch at the Soho works of a century ago, because they have become so intermingled with the inventions of other great men, Maudslay, Bentham, Brunel, Blanchard, Whitworth, Nasmyth, Greenwood, and many others who in different countries have each done their part, and we can trace the mark of one or another in the greater number of the machine tools, and more especially in those from all European nations. From the close thinking which has been expended upon this class of machinery of late years, the avenues leading to marked improvement have been so closed up that it is now rare to find great novelty amongst them. There is a great transposition going on, but even in that respect there is not so much change as might be expected, the most conspicuous universal improvement being in regard to quality. Notwithstanding the fact that it is to the honoured names of many of our own countrymen, both of the past and the present, that the world is so largely indebted for the designs of many of its best tools and machinery (a fact which is fully acknowledged by all who are acquainted with the past history of such mechanism), yet we must not forget that mankind generally do not know, neither do they care much for the source of these contrivances; they are oftener guided by other considerations, chiefly those of a commercial nature, and in the present condition of the world's progress our country throws a grand chance away when its display at these Exhibitions is not upheld by the best specimens of her numerous branches of machine-making and other manufactures.

Before reporting upon the details of the machinery exhibit, there are a few prominent subjects that have yet to be referred to, which are of general interest to all who are intimately connected with the question. From the wide diffusion of knowledge in regard to machinery, and the deep interest attached to the subject, every collateral question was discussed more fully by the people of different nations than has formerly been the case, either in Paris or in London, more particularly with reference to quality, style, precision of test in order to ascertain quality, copying from each other, and such like. With reference to quality, it was generally agreed upon that for high speeds perfect balance was essential; in this respect there were many deficiencies in the specimens submitted from all countries in some of the best machines, and even in the governors of steam engines, the parts were seen to "wabble" from not being in equilibrium. In some instances this arose from

imperfect teeth in wheels, and the pinion being too remote from the bearing. A second essential condition is absolute truth in the running parts; it might be supposed that the want of this condition would have been of rare occurrence, but such was not the case. A spur wheel of one of the best English engines was literally on the swing, and the same may be said of many other wheels running at high speed. A third essential was in the selection of the proper quality of iron for a particular purpose. In regard to this point the failure was almost general; some twenty of the leading houses of all nations excepted. A fourth condition in regard to machine tools is, that no filing or polishing shall be necessary, but that the articles shall be finished by the machine fit for their destination. In regard to this point there were few means of testing and judging. Sharp, Stewart and Co., of Manchester, was a notable example. Every machine sent to the Exhibition by that firm had a connecting rod, crank, wheel, or some other article in them to show what the several tools could really do, which attracted great attention and was highly commended. The lathe beds of the best houses of all nations were left with the surfaces from the planing tools, thus showing how ideas spread; for in Paris in 1867 this was comparatively rare, but it implies a refinement of workmanship due to knowledge, good planing machines in the workshop, and an economical system of manufacture. For sterling quality in most of these respects an English firm probably stood the highest; their display of articles was however much too limited so far as England is concerned, and the position in the building assigned to this particular firm was unfortunately not the best, but all their several articles were perhaps, of any shown, the nearest to being faultless, if not entirely so, and they compared favourably with any other exhibit. The reservation in the foregoing sentence is due to a very trifling matter, namely, the form of the teeth in a particular worm wheel, which only the severest hypercriticism called in question; and without a single dissent the highest honour was awarded to this house, not only for the present display, but likewise for the continued excellence which has so long been maintained at the Atlas Works of Sharp, Stewart and Co. There was no attempt at show or polish, and taken simply as tools, either individually or collectively, this limited exhibit stood out distinctly as the most worthy of careful study by any one who is desirous of knowing what such tools ought to be; and although they have but few novelties to recommend them, still, their

harmony and beauty of outline in every detail, their evident fitness for the intended purpose, and the extreme care which must have been employed in the selection and remelting of the iron in order to bring it to the required degree of hardness and closeness of structure for certain parts, are deserving of great attention; and in addition to this, their machines were altogether so carefully got up in regard to the mathematical accuracy of their working parts, such as straight lines, true circles, flat surfaces, facilities for adjustment after wear, and the precise accuracy of all parts which are concerned in the transfer of their condition (either of form or surface) to the articles operated upon, that this combination of general excellence made them an object of interest to all who were capable of appreciating their good points, more especially to the continental and American engineers, whose expressions of admiration were unbounded. Almost the same general remarks would apply equally to the celebrated house of Sellers and Co., of Philadelphia, who also received the diploma of honour, and whose tools possess more originality, although perhaps accompanied with more faults when very critically examined; but, be that as it may, every article which they displayed takes rank with the best of its kind shown in this Exhibition, and altogether this American collection possessed more real novelty and attracted a greater number of admirers than that of any other firm in the machinery part of the building.

The two firms above referred to, the one English, the other American, are both typical machine-making houses of their respective nations, and they offer a strong resemblance and contrast; both have arrived so near to the summit of the tool art that it is difficult to say which of them stands the higher. Sellers and Co. show decidedly a greater exuberance of fresh design, but the devices introduced are sometimes less perfectly combined or arranged than they might be by other hands; and while the English firm shows comparatively little fresh ingenuity, yet every feature of their products bespeaks the matured thought of the experienced engineer. To select for comparison, one example, namely, the planing machine which originated with Sellers and Co., but which was made and exhibited by each firm; both of these planing machines are nearly alike in their general character, but in some of the details the difference is considerable: for instance, the Messrs. Sellers crowd the driving gear into the close vicinity of the most important part of the machine, where it must evidently be inconvenient and in the way of the workman;

but the other firm, from its long experience, without sacrificing any of the essential points, has contrived to place the gearing entirely out of the way of the attendant, thus making it in general opinion the better machine of the two. To many, the careful examination of the entire display of both firms was a real treat, the castings of both houses were works of art, to look upon which caused the breast of the beholder to heave with admiration, and after a close scrutiny of the products of both firms, the general conclusion was, that Sellers and Co., while showing higher refinement, descended lower than the English firm in some of the details, but that the latter, as a whole, sustained its reputation and excellence more uniformly.

As a general rule, America had the greatest number of new devices, but with the exception of Sellers, this country was in other respect not quite up to the European style or standard. Nevertheless, in the general opinion, the precision of the greater number of the American machines, especially in the extreme refinement of their details, was fully ahead of that of the best European ones, while some of the attempts at copying the English style in regard to solidity of construction were not so successful, sometimes approaching even to clumsiness, and consistency of character was not maintained throughout; at the same time, where the American firms adhered to the genuine style of their own country their consistency was marvellous, although depending more on their intuition than on calculation. The many interesting products from that country had a distinct character, namely, that of originality, yet there was not much of a very remarkable nature, and, with some exceptions to be hereafter referred to, not of very great importance, but still their novelty in combination with first-class workmanship was most conspicuous; besides, the American novelties are not of the kind that emanate from the drawing office, they are more the result of the quiet thinking of earnest practical men, and however they may fail in other respects, it is not in regard to fitness for their intended purpose. The besetting fault of the second-class American houses is the attempt at finery, both in regard to form and painting or ornamentation. No doubt the teaching of exhibitions will soon remove that tendency. By listening to the praise which was so freely bestowed upon the productions of Sellers, Platt, Sharp, Tangye Bros., and some of the Chemnitz houses, the American machine makers will soon learn that the inherent natural beauty of their own productions requires no artificial adornment. This circumstance of

America having a larger share of originality in her machine compositions than any other nation is not easy to account for; their display was not extensive nor particularly striking, but almost every article had some interesting feature which attracted the attention of students from all countries, and from our people they received more examination than was given to the exhibits of all the rest of the world. With the few exceptions already referred to, the American novelties were not important, but they were all improvements tending in a particular direction, precision and labour saving, and in advancing the gradual triumph of the human mind over matter. Why the American genius for originality should be so active is somewhat obscure, because the same kind of hard necessity, commonly said to be "the prolific mother of invention," exists elsewhere; it certainly is not due to scientific education, for America in that respect, is, at the present time, far behind Germany. The latter country, in all the grandeur of her vast display, seems a barren wilderness in regard to invention when compared with America, and yet these Americans were mostly of the Saxon or Teuton stock, hard-headed thinking men and extremely modest in their pretensions. To meet with such clear thinking studious men is one of the chief pleasures and advantages to be derived from international exhibitions, and helps to spread a civilizing influence, perhaps more than even the exhibition of the inventions of the world to the passing public.

If space permitted, it would be equally instructive to run over the machines of the entire Exhibition. France, Belgium, Switzerland, Sweden, Germany, Austria, and Russia were all represented and all showed great progress. As might have been expected, Austria made an extensive and most magnificent display of almost every description of machinery, and many of her machine tools, more especially those for wood working, were fully equal to the best of any country, and were finished in the highest style of constructive art; the vertical frame sawing machinery of Vienna was unrivalled, and of the collection that was shown by the firm of Pfaff, Fernau and Co., of Vienna, any country might well be proud. Every one of their machine tools would prove a formidable rival to the best of its kind of any other country. This exhibit was the object of much admiration; the machines had much of the grace combined with the solidity of English tools, and many of them showed a considerable amount of originality in regard to special fitness for their intended purpose. The general style

of their tools had considerable resemblance to those of the same class as made by Fairbairn of Leeds, Whitworth, and Sharp, and they were not, like many of the tools exhibited by some of the Saxon houses, mere copies, but had been well thought out by themselves, and good common sense was brought to bear upon their details. In some of their face-lathes the shifting head-stock was dispensed with, thus showing, as a straw shows how the wind blows, that in Austria they must be paying some attention to a good system in the arranging of work in the factory; some of their smaller slide-rests were not adjusted in what we consider the best manner, but by pinching-screws; these were employed to push the angle piece which rested upon a plain surface, instead of using a solid fixing with bolts and nuts; but in their heavier tools they employ the better method, similar in arrangement to that of Sharp, Stewart and Co. Besides the house of Pfaff and Co., there were many others who made tools that were better than any tools 25 years ago. Austria is making great strides in many directions, and notably in engineering; their iron is of remarkably fine quality, and some of the castings shown, as well as the forgings, (both from her own provinces) were all first class and considerably above the average. Austrian workmen employed in the Exhibition did not seem to possess much vigour, nor were they equal to the English in regard to engineering aptitude; their work was not so purpose-like as the tools exhibited; their appreciation of doing things properly seems deficient, pipes for example, and other things were put up without much regard to being on the square, and so forth, all comparative trifles in themselves, but yet they show that the mechanical teaching in Austria is not so inbred as it is in England, that it has come down from the masters to the workmen, and therefore the reverse of the English system; still in the course of another generation the inherent mechanical nature may grow into their nature in the same manner as it has done into the British. There is more in this question than is usually recognised.

The finest and most beautiful heavy lathe in the whole Exhibition was from F. Zimmermann, of Buda Pesth, in Hungaria. This decision was willingly granted by the men of all nations. The most careful study had been bestowed upon every line which met the eye, and the workmanship was equal to the design, both being simply exquisite, and altogether it was probably the most matured piece of lathe work which has yet been made in any country; there was

no attempt at polish or ornament, it was plain and simple throughout, with the bed surfaces just as they left the planing machines; at the same time it was not perfect, the bed was constructed in two parallel pieces, (possibly to accommodate the capability of the foundry,) and besides, it had less mass in the entire bed than English experience shows to be desirable; this objection was met on the ground that it is extravagance to give the necessary mass in iron, that it is more economical to give it in a stone foundation, found at the locality for which the lathe is destined. There is some reason in this, for it is evident that the transport of some of the lathes that were in the Exhibition would prove a most expensive item if requiring to be sent to a distant part of the world. There was difference of opinion expressed on those points, but all were of one mind in regard to the simple grandeur of this lathe, and the feeling of repose which it excited in the mind of the careful observer.

The largest collection of machine tools shown by any single house was probably that of Ducommun, of Mulhouse, in Alsace, the next being that of the large Saxon firms of Chemnitz, all of which were of the first-class order; extensive displays were likewise made by many of the French and German engineers, and so good were they, as a general rule, that at first sight they looked equal to Sharp's or Sellers', but after a closer scrutiny a good many faults were to be detected. With regard to France, her improvement since 1862 is a matter of astonishment, and even since 1867 it is very considerable; comparing the display that was made by Deny of Paris in the latter year with that now shown by them at Vienna, the difference is great; here we find that all the old world forms have been abandoned, and the most modern and refined style of construction has been substituted; still France as a whole had little of extraordinary merit to show in this section, but almost everything which that country did put forward was very good of its kind, and combined with a fair share of that sort of ingenuity which refers to important details affecting the working of machine tools. For instance, Arbey of Paris sets a good example to all makers of wood machinery in regard to the mode of fixing the planing knives that revolve at a high speed, and likewise in the manner of sharpening them. In the French machine, the knife is a curved slip of sheet steel, tempered; it is wound in a spiral fashion around a properly prepared cylinder, and enveloped in a suitable iron covering, but with the cutting edge exposed; thus the cutting edge,

although a spiral, is developed into a portion of the surface of a plain cylinder, across the face of which there may at any time be passed a revolving emery wheel, in order to sharpen the edge of the spiral blade; besides, from the construction, the rapidly revolving spindle is in a condition of equilibrium, and the effect of centrifugal force upon the cutting instrument is frustrated, thereby entirely preventing the cutters from flying outwards: this is one of the useful lessons taught by the Exhibition, and was greatly admired, and is considered an important improvement upon the usual manner of fixing such instruments by a pinching screw on a flat surface, with all its attendant trouble, coupled with the risk of accident; indeed, considering the speed at which some of these spindles were made to revolve at Vienna, it was a marvel that serious accidents were not frequent. M. Périn, the inventor of the ribbon-saw, came out in full force with an extensive assortment of fine tools carefully studied in every detail, and his saws are still allowed to be the best to be found anywhere. Taken altogether, France was true to herself, her exhibit was in all respects fully equal to the capability of the nation, and as regards extent, it was relatively far beyond England in the machinery section.

It was also made perfectly clear to any impartial observer that some of the French and German houses have almost arrived at the same perfection as our own best houses, and the amount and variety of the grand displays which they severally made was enormous, thereby showing us unmistakeably the prodigious strides that they have both made during the past 20 years. Considering distance from Vienna, by far the greatest national effort to come out in full strength was made by Germany, her best houses all came forward with an immense collection from each, the greater number being first class, and the combined effect of the whole was overpowering, evidently showing a consciousness of inherent active strength, and an intense earnestness of purpose to astonish the world, which they did most nobly. Germany is in earnest, her competition will be down upon us before we are aware, and with the great learning imparted to all her workmen she will yet prove a most formidable rival; hence, with us, it is the duty of every man who loves his country, to put our young men upon an equal footing, so that the rivalry may not be overwhelming. It was interesting to trace in the German division certain peculiarities in their machinery, probably due to the manner of their mechanical school training, that

is to say, the mechanical teaching came downwards before the practical knowledge of the people was brought up to the point that would have enabled them to apply the science school knowledge properly. The designs of the German tools mostly came from England, and so far as the general outline is concerned, the eye fails to discover any difference between them and our own, but on minute examination many peculiarities are to be detected, which draughtsmen have passed on to the workshops from want of that inbred practical tuition which is necessary to keep them right: there is scarcely one German lathe in the Vienna Exhibition where the handles of the slide-rest and the saddle would clear each other; this may seem a trifle, and would be so in a solitary instance, but being so general, the inference is that the cause lies deeper and is not due to chance. Or, to take another example, of a fine drilling machine of noble proportion in the Chemnitz group that was marred by an additional fixing in order to secure the table, which was not in the English original from which the design was taken; if the workmanship of the table had been sound then the fixing was not wanted, but if, owing to bad fitting, it was required, then the fixing which was put on would be practically useless, because it had not sufficient strength or substance to resist any strain that would overcome the steadiness of the table. German greatness for the present does not spring from inherent inventive power, that virtue may come in course of time, but it will have to come upwards when the German mind is imbued with the practical teaching of the workshop.

Belgium and Sweden were both at the gathering; it was difficult to perceive much change in the former since 1867, her machine tools were not of the first class, but resembled some of the English tools that have not yet been mentioned, even her lathe beds were filed (some said polished) after being planed: this shows the type. There has always been a want of refinement and character in the Belgian tools when closely examined, at the same time there is an evident ambition to do well, although they have not caught hold of the spirit which animates the modern style either in regard to construction or workmanship. In their textile group, however, there was one of the most original machines in the whole Exhibition, the invention of M. Martin, of Verviers, which is a marvel of ingenuity and will prove a rival to another equally ingenious machine in the American group by Mr. Avery; both are intended to perform the same office, but are contrived on entirely different

principles of construction, they are both for wool-spinning, and are intended to supersede the mule. Each of these two machines teach one of the lessons of the Exhibition, and will be referred to again in this report in the proper place.

Sweden has done well at Vienna; her collection was not large but it was good; it contained fresh ideas and likewise taught an important lesson. Hitherto there have been numerous attempts to make corks by machinery, but the difficulty of keeping the cutting instruments sharp has always been a drawback. Sweden, however, has overcome this obstacle, and by very simple means; an emery wheel revolves beside every instrument, and after each cut the machine is sufficiently automatic to place the grinder in contact with the edge of the revolving instrument for a single instant, and thus it works on continuously without any stoppage for sharpening. This is evidently right, but the principle will not be long confined to corks, for in this Exhibition it was applied by four different houses for various purposes, and therefore the makers of machine tools for wood must study the question: there is a wide field open, and much ingenuity will be required to carry it into successful operation.

Switzerland always makes a good display, but never before made one so good as at Vienna. Some of the machine tools were superb, with a refinement rarely to be met with, and her workmanship as a rule is good, although not perfect in every respect; still the improvement is so marked at each successive Exhibition as to show that the people of that country are well fitted with a natural aptitude for machine making. The Swiss machinery for making macaroni, and more especially the instrument through which the material is squirted, was perfection, and far in advance of any such machinery previously exhibited. That country likewise exhibited a remarkable lace-making machine, entirely new, and probably the most ingenious piece of mechanism of that nature which has yet been contrived. This machine is capable of working with a hundred needles, and the combined effect of its action with them was a marvel to witness, and was an object of great attraction both to the engineers and the general public.

Russia had a greater display of machinery than she has ever made before; the model of a steam hammer of enormous dimensions was shown, and was really very superior; her machine tools likewise were passable, but savour too much of the technical school at the present time, and

after seeing the exhibits of Germany and Austria, that of Russia was in some measure eclipsed; still, it is evident that the latter country is improving.

In this hurried general reference nothing has been said of the common tools and bad ones; of both descriptions there was an abundant supply. In the provincial towns of both the German and Austrian empires there is a demand for the class of articles that are frequently to be seen in the neighbourhood of Clerkenwell, London; these were to be found in great variety at Vienna, the makers of such articles being anxious to contribute their mites towards the great gathering, and this was a right feeling and highly commendable; the tools here referred to are wanted, and consequently have a market, and by coming to the Exhibition their makers will have learnt much good, and have returned to their homes with new ideas of the wonderful improvements which the rest of the world has been making during the past hundred years. It was interesting to observe the enthusiasm with which they spoke of all that they witnessed at Vienna, although it was evidently too much for them to realise all at once; for, lying out of the reach of modern machinery, their minds were not sufficiently prepared to take in either the object of the machine or the principles applied, or indeed scarcely the mechanism, yet for all this, the amount of real knowledge which was thus sown broadcast over the extensive regions of Eastern Europe must of necessity be highly advantageous for all concerned.

The improving influence of these international exhibitions, more especially on the minds of the thinking class, (in which the machine makers and engineers are generally comprised) was clearly shown at Vienna in the discussions that arose upon points which at former times were scarcely ever touched upon. At the same time it was observable that some of our people were not previously educated up to the proper artistic feeling, and therefore some of the things sent to Vienna were to themselves a matter of subsequent regret; at the first, men were disposed to defend faults of construction, but it was not so afterwards, thus showing the value of the teaching process. In regard to such obvious defects as want of truth or equilibrium there was no difference of opinion, even the cleaning attendants were observed to blush when passing visitors looked at the blemish; at the same time it was evident that such defects were less numerous than in 1867 at Paris, and that the general surfaces were more truthful at Vienna. In 1867

the scraping of metallic surfaces for mere show was quite common, but this year it was to be rarely met with, although one house in its simplicity had scraped the brighter parts of their machines into a chequered pattern of diamonds, a proceeding which can impose upon no man with any knowledge of tool construction, and who must be aware that the road leading to a true surface cannot lie in that direction; therefore the conceit, although silly, was harmless, whereas the sham scraping system alluded to was gradually creeping in, by which the inferior houses were giving their machines the appearance of having been scraped for a true surface, while it was only a make-believe, and was a highly dishonest imposition upon the public.

The question of superior excellence in tools was often raised, both in regard to the necessity as well as in its commercial aspect, and the depreciatory remark was frequently made that machine tools were manufactured in order to be sold, that perfection is not the great object for attainment by the tool maker and that it is unnecessary. This is of course an entire mistake. That man who knows what a good lathe or tool really ought to be, and who is capable of making it, will not construct a bad one, for if simple enough to do so he would be working against his own interest. It is a common error to suppose that inferior houses by much painstaking may thereby make good machine tools for an Exhibition: this cannot be done, it is impossible; good things cannot be commanded at will in such a manner; perfection is a consequence of constant persevering effort continued for a number of years, and by all who are engaged in the production being well trained to their several duties; it is only such a course of training that enables skilled and intelligent men to know what they have to strive after, for even in such an apparently simple matter as the proper selection of iron or other material for the respective parts, whether for steam engines or machine tools, what contrasts were presented on looking round this Exhibition! For example, the metal chosen by the English house of Sharp, Stewart and Co., for the important parts of their tools, or that selected by the French house of Schneider and Co., of the Creuzot Works, for portions of their steam engines, more resembles cast-steel than cast-iron, so close is its structure, that is to say, there is such an absence of porosity and it is of such silvery brightness; it bears no comparison with the dull soft porous iron used by many other houses, or in quantity with the mass of material which is frequently

thrown in without regard either to proportion or sense. There were many tools in this Exhibition that must have been designed and made by men who have not yet learned the alphabet of machine tool making, the forms given to some of the parts were entirely at variance with the laws of nature which determine form and proportion, and in too many examples the ideas of men have been allowed to run wild by carrying out these conditions in accordance with some imaginary laws of their own. Natural form consists in giving to each part the exact proportion that will enable it to fulfil its duty with the smallest expenditure of material, and in placing each portion of the material under the most favourable conditions of position which the circumstances will admit of; such natural form is always correct and beautiful.

It would serve no useful purpose to say much about the inferior tools that were sent to Vienna. Of such articles we certainly contributed our share, although we were not by any means alone, and it was hopeful to observe the general feeling of disgust that was manifested by our own people in regard to all such articles of inferiority, as by seeing such contrasts, with the good and inferior placed side by side, a useful lesson may thereby be imparted to us all. Some of our own tools even could not be looked at without a shudder; there were bad designs, bad copies of good designs, bad castings and inferior workmanship, even to the paint and putty, both of which were badly put on, and there prevailed an utter want of harmony of construction both singly as machines and as the united products of a single firm. The discordance which is here complained of does not cause the same pain in all men alike, because some can look at such imperfectly harmonised machines or tools with complete indifference, in the way that others can listen to discordant music without observing the want of harmony. To the trained observer the effect produced by the accordance of a perfect machine or tool is similar to that given by the strains of fine music, which to the refined ear afford extreme pleasure, while any fault of the player calls forth an inward expression of shock and pain; so it was when examining some of the machine tools which were exhibited, not English tools alone, but likewise some of those sent from other countries. The want of harmony in some tools, and the evidence of imperfections that are to be met with daily are all disturbing in their effect upon the mind of the cultivated student, and cause a similar inward feeling to the shock produced by hearing bad music.

It might be supposed that with so many good patterns before the world, any machine maker could, at pleasure, commence tool making by merely copying the forms of Whitworth, Sharp, or Sellers; and, with the great learning existing in the German workshops and drawing offices, that nation more especially should experience no difficulty in copying the best examples; but a ramble through this Exhibition clearly showed that it is not so easy to copy correctly as might be supposed. The attempts to transcribe good specimens, however, are very numerous, but in the larger proportion of cases they fail: a man must first see the points that have to be copied before he can copy. There is a defect in some men termed "colour-blindness," which unfits them for copying a painting, and it is the same with the class of machines here referred to; a man must first be trained to know the points of excellence, otherwise he will only imitate; for just as a fine picture cannot be copied by an inferior artist so we may see precisely the same result in regard to machine tools; any number of the picture imitations can be produced, but they require the effect that constitutes their value, and although the unskilful artist may not see the defects himself, or may even fail to perceive any difference between the two pictures, yet an expert will detect and be able to point out many imperfections in the imitation which cannot be found in the original picture. It is the same with machines; as a rule, the man or firm capable of copying will not do so in the literal sense, because the house that has the minutiæ of knowledge sufficient to see the nice points on which excellence depends so as to enable it to copy correctly, will not stoop to do so literally; it will as a rule strike out a path for itself; but those who copy generally fail to catch the numerous points on which fitness for a purpose depends.

In consequence of the enormous extent of the Vienna Exhibition another important question presented itself, namely, with reference to the system of selecting machinery for competition, and especially in regard to the manner of ascertaining their relative value as machines. In view of future International Exhibitions, this subject came home to the British exhibitors and visitors more keenly from the circumstance of feeling that we were not so well represented as we might have been in some sections; for although our display as a whole was very good so far as it extended, yet, owing to the fact that a considerable number of the tools sent from England were inferior both in style and quality, and were made by firms which are scarcely ready for such

competition, it was evident that some new regulation must be adopted. The question was frequently raised in regard to the best course to be pursued in selecting the articles that should be submitted for exhibition; many doubts were expressed in regard to the wisdom of the present system in allowing exhibitors to put forward any articles which they please, because such a course lays the nation open to the charge that it is retrogressing; the general impression was, that England must organise a system, in connexion with the Government if possible, but if this cannot be done, that a General Association should be formed to act in conjunction with the Government, so that in future our nation may be properly represented. The time has arrived when we must put ourselves right before the world and dissipate the notion that we are going backwards, when in reality such is not the case; still, from the fact of inferior machines having been exhibited at Vienna in large quantity, the nation was laid open to the charge, and it had to be met again and again. It is not in the nature of things that our rivals will take our lenient view of these circumstances, hence it comes to be a necessity that every tool exhibited shall be the very best of its kind, and require neither praise nor apology from those who may have to make the best of them. It has hitherto been a fortunate circumstance for the inferior class of articles that no real test has yet been applied at Exhibitions in order to ascertain precisely how good or how bad the respective machines may be; but as competition increases, the houses which aim at high quality, will, in self-defence, be compelled to press for actual testing in order to fix their relative positions; this was exemplified to some extent at Vienna by some of the makers of wood machinery; the whole of the English exhibitors and a few of the leading continental houses were eager to show what they could do, while the majority held back and did not put their machinery in motion. Of those who did attempt to work their machines few ever reached to the high standard expected, and certainly the general effect produced in wood working was not equal to that shown by some of the private establishments in Vienna, nor equal to what may be seen daily in England; no doubt this inefficiency was chiefly due to imperfect foundations, an insufficiency of power, and to a variety of other causes. None of these attempts at working were conducted systematically, and, when strictly considered, were not really competitive, but merely a show of what the several machines could accomplish, and so far, some of the English machines performed their work as well as any in

the Exhibition, and in the opinion of the writer even better than any other as regards quantity of produce; still, from want of systematic organisation, this could not be affirmed, and probably England would have received an additional diploma of honour if the working of the machines had been properly organised, and it will be to the interest of the best firms to have rigid testing.

The test for such machines is, to ascertain correctly their relative accuracy of production, their adaptation for great speed, and the general soundness of construction combined with simplicity. Many a good-looking machine when carefully scrutinized by rigid means would be found sadly deficient, but as it would be impossible to test every machine, as a compromise let only the best specimens of those countries which desire to compete for honours be subjected to the strictest investigation, so that the best only may gain the prize. The feeling prevailed that the present system is not exactly what it should be, both in regard to the selection of that class of articles which can be readily tested, and likewise in the manner of arranging them for comparison. Perhaps nothing could have been better than the arrangements made at Vienna for the great majority of the various kinds of articles exhibited; but for the highest class of machine tools the competing firms ought to be placed closer together for competition, namely, for each nation to put forward her best specimens as selected from the cream of all her leading makers, and instead of the various sorts of such machinery belonging to an exhibitor being all in one group as has been the custom since 1851, let them be arranged in separate groups for a rigid comparison with their competitors, each group containing but one class of articles, lathes, drilling machines, and the like. To select the slide lathe as an example, let the 12-inch or similar sized lathes of all nations (upon which they are severally prepared to stake their reputation as slide-lathe makers) be ranged side by side for strict examination in regard to truth, roundness of spindles, parallelism of slides, means of adjustment, fitness for accuracy both in boring and turning, and their capability in regard to quantity of production in a given time. The same with drilling machines, more especially in regard to the relative parallelism of the spindle to the table; few machines are strictly correct in this particular if tested with the spindle and table in every position, a ten-feet straight-edge laid on the table and a five-feet scriber attached to the spindle and carefully moved from one end of the straight edge to the other at the different adjustments, would cause

the maker of many a brilliant looking drilling machine to haul down his colours and stand to one side in the contest. Any system of competition, in which the examination does not go to the root of the matter, as here suggested, is not real, and the truly good makers are confounded with those who are satisfied with an approximation to accuracy, and if such tools are not accurate they are only a snare. Such a test as this would not only bring out the several merits and defects in each machine and enable a more correct comparison to be made, but it is really necessary, from the fact that Exhibitions have now become so large, and the labour of examining carefully has become so great by the present system, that the critical examination is in consequence much too rapidly conducted, and therefore too superficial; but if only the very best machines were to be submitted for testing, and were all brought together in separate groups, there would then be some hope of putting them to a test that would be satisfactory to every one, as the relative merits of each lathe or tool would be positively ascertained.

In order to carry out such a system, it is suggested, for consideration, that before another Universal Exhibition comes round there should first be held a national display in each country, at which a jury of its own experts should select the articles that are to be put forward in the following year at the International. Upon arriving at this latter Exhibition, the exhibitor, with reference to each competing article, should be called upon to state in writing the point or points of each machine for which he claims merit, whether for progress, design, workmanship, or otherwise; this declaration should be published by hanging the statement upon the machine as a kind of challenge, and his competitors ought then to have the opportunity of being heard thereupon, the function of the jurors being merely to hear, examine, discriminate, and award; by some such method of procedure it would be possible for jurors to deal out even justice to all alike as depending upon real merit.

Never did any body of men go to work with a greater desire to act fairly to every exhibitor than the jurors of Vienna, but the task set before them in some of the sections was so great and had to be carried out so hurriedly from the many thousands of machines which had all to be looked at and passed through their minds for a decision, that it is quite a possibility that some merit may unintentionally have been overlooked, or that some machines obtained more credit than they really deserved had the truth been known.

In addition to the foregoing system of testing there is

something further wanted to bring out all the teaching which a rigid process is capable of yielding as lessons to the world. When the testing is accomplished, and all the good and bad points are carefully analysed, then, in order to give the full benefit to the tool-making centres of all countries, it would be further necessary that some qualified man should be appointed to tabulate all the points, both good and bad, and write an accurate and impartial criticism upon each article, pointing out the minutiæ of wherein they are perfect or imperfect, as determined and shown by the contest. Such a criticism, removed from the domain of mere opinion, would be invaluable to us all.

The important subject relating to the copying of designs of other makers was a frequent source of conversation and warm discussion, much more so than was the case at Paris in 1867, or at London in 1862. The formidable competition that stares us in the face no doubt excites the instinct of self-preservation, and hence the complaints of certain British exhibitors were loud against some of the continental tool makers (more especially those of Saxony) for copying our best forms and arrangements in a manner which the former considered too flagrant. The men of Chemnitz, however, very justly retorted that they only followed the example of many British makers who do precisely the same; that the majority of English lathe-beds, headstocks, and spindle arrangements are merely imitations of the devices of Fox, Roberts, Sharp, Whitworth, Greenwood, and a few others; that we are as ready to adopt American improvements as the continental firms have been to adopt the English, and that "men who live in glass houses should not be the first to throw stones." It must be allowed that there is truth in both statements. All our best models are repeated over and over again by many of the continental houses in the same manner as Whitworth has been copied in England, still there seems to be no remedy that could be devised to prevent it, unless all were to come to a common understanding on the question and declare it dishonourable; but as this seems impossible at the present time, it would appear that the sooner we can get rid of this "bone of contention" the better it will be for all nations. It is quite true that in 1851 we stood alone; that in 1862 Saxony came forward with a display which, although limited, took England by surprise; in 1867 they made a grand show, almost equal to our own, and then at Vienna they made a still further display, which pushed England into the background before the eyes of the world. The blame, however,

rests entirely upon ourselves. The prodigious advance made by Saxony is not due to chance, it is a consequence of their inherent capacity for tool making, a talent which exists as much in the blood of the Saxon as in the Anglo-Saxon men of Lancashire, and it shows, as much as any ethnological evidence, that both are from the same line of the Aryan stock, and that the fact of Lancashire being the first in the field was an accident due to the inventions of Watt and Arkwright. Both peoples are evidently gifted by nature to be great in tool-making, and hence it is useless to regret this matter any longer, but rather advisable to put a good face upon it and accept the fact. Their preference, as shown by the copying of our tools, is a compliment to our own nation, and if the circumstances had been reversed, it is more than probable that we should have done the same, more especially if our training had come from them through the drawing office or the college, instead of through the smithy, as was fortunately the case.

Seeing, therefore, that there is no law to prevent such a system of imitation, and knowing that the customers for such tools will not as a rule consider the question of selection upon those grounds, but will, so far as their knowledge extends, purchase the best machines for their requirements at the lowest price, the great lesson taught by these circumstances is self-evident, namely, that each maker must aim at perfection for himself, use every means to produce economically, and then abide the result, and if such means do not insure success, he will not only have the satisfaction of feeling that he deserves it, but he may rest assured that his perfection of mechanism cannot be imitated without natural aptitude and years of earnest study, just as much as in becoming perfect in a foreign language. A mere imitation does not necessarily secure the points of excellence. We have abundant evidence of this in every direction, and this Exhibition of 1873 offered many illustrations familiar to all.

To take as an example the case of the Sultzer Corliss engine, which was first exhibited at Paris in 1867, and was at that time admitted to be the best in that grand collection. That engine has had some imitators who have endeavoured to copy it. They have chiefly succeeded in securing the defects, but at the same time have lost sight of some of the more important points, while Sultzer himself came forth at Vienna in 1873 with the same engine improved, and stood very far in advance of any of his imitators. Or to select an example in tools. The mode of working a slide-lathe, exhibited at Paris in 1867 by Sellers of Philadelphia, is the

best contrivance probably yet introduced for the special purpose, but here in Vienna there was not a single lathe furnished with this device except from America, and the reason given for the omission was, that it had been tried, but that the discs which grip the inner disc are apt to wear at particular parts, showing that the design only succeeds when having Sellers' refinement of workmanship and quality of material. It is a simple contrivance which enables a turner to obtain any rate of feed without a change of strap or wheel motion, by merely touching a handle, and it ought to commend itself to all tool makers, who should continue to persevere until they overcome any such difficulty as that named above, in order to supply their customers with only that which is the very best for the purpose. There is not the smallest disgrace, but rather the contrary, for one house to accept and adopt any designs of another which they may consider superior to or an improvement upon their own. This is frequently and satisfactorily arranged by houses of the highest standing in all countries, and if it were the general rule the disputes previously alluded to would be avoided. A case occurred at Vienna where a foreign exhibitor had an exact copy of an original machine, which gave rise to an angry complaint from the representative of an inventor who followed the jurors into the exhibit of the house which had copied without permission, and there pointed out the appropriation. An amicable settlement was however arrived at, and the promise was made that in future the name of the designer should be placed above the secondary maker. Even this concession would be no small matter if it were generally followed, seeing that the designer's name with the word "system" appended, would serve as an introduction to other customers, who would in many cases give him the preference. A notable instance in regard to the omission of the name of the inventor is in that of the steam hammer. At Vienna there were gathered a large number of such hammers from many countries, England included, but Nasmyth's name was not upon one of them, yet every one of those exhibited was a Nasmyth in most of the leading features—the vertical cylinder, the guiding standards, and the hammer raised by the direct action of the steam; while at the same time the names of many other makers were to be seen, such as those who had made some modification or improvement afterwards, "Naylor's system," for example, and other systems were acknowledged, and although those designations were very properly employed by foreign makers, the name of the first inventor should

not be ignored. On the question being raised, it was said that the original name was omitted because it was unnecessary, as all the world knows that Mr. Nasmyth was the great originator of the steam hammer, and that his name was implied in the same manner as Watts for the separate condenser; but how far this explanation may be considered satisfactory it is difficult to say, because the world is so apt to forget from whence the best devices come. How few of those who went through that Exhibition could tell the name of the man who first thought of the various devices, yet every one of the many thousand schemes shown at Vienna emanated from some brain, even to the simple contrivance of the fast and loose pulley, appreciated everywhere as the most perfect arrangement yet invented for its special purpose. We cannot name the individual who thought of and originated it, therefore no diploma of honour could be awarded to him. It is however, desirable, now that machinery is becoming such a prominent power in the world, that the originator when known should be acknowledged, and it is all the more necessary to enable us to trace the history and the path which led on to other ideas. Perhaps the finest pair of marine engines yet produced by France, or any country, were those exhibited at Vienna by Schneider and Co., the leading firm in France. These engines were not large, but were perfect in many respects, yet comparatively few of those who were struck with admiration seemed to know that the original of this style of construction came from the same mind as the steam hammer. Nasmyth's "Infant Hercules" was the forerunner of all the steam hammer engines that have yet been made from that type which is now being so extensively employed for working the screw propeller of steam vessels.

If space permitted it might be profitable to refer to a number of other general questions which arise in connexion with, and are suggested by the working of these exhibitions, in order to lead on to a gradual improvement in the future. In the nature of things perfection is not to be arrived at all at once; defects will creep into the best arrangements, and with the best intentions, yet it is hoped that by calling attention to them in these reports a change for the better will be perceptible at each successive International meeting. An important lesson might have been derived from a comparison of the details of the Exhibition at Vienna, but as such items were to be reckoned by thousands they were too numerous for any single individual even to observe, except by allowing sufficient time to look them up systematically

and to note the points of merit contained in them; these conditions were, however, not at the command of the jurors. A knowledge of the details would enable a more correct opinion to be made of the relation of one country to another, than could be obtained by a hurried inspection of the completed machinery as prepared for the rivalry of an exhibition, where the eyes of all the staff of the respective firms are concentrated upon the several machines, and on the look out for imperfections.

On looking round the Exhibition in order to examine the evidence afforded by some of the subsidiary workshop appliances shown by different countries, the impression left on the mind of the writer was, that in this respect, we are yet in advance of all nations, not that our exhibit would have indicated such a superiority, but judging rather by what we know to exist in British workshops.

Almost every contrivance of the past in mechanical detail which has found its way into books or has been previously exhibited was shown by some country, and no doubt that to those who are not fully acquainted with what exists elsewhere it might appear as though many of the things exhibited were real novelties, whereas it is otherwise. In some English factories many of them would be considered old fashioned and not worth exhibiting. To select the familiar contrivance called a chuck as an illustration; by far the best chucks in the Exhibition were shown by America, and they were very good of the sort, but there will be found in the Royal Arsenal at Woolwich at least forty constructions of chucks used in connexion with the manufacture of shot, shell, fuzes, and a variety of other things, and adapted for chucking either from the inside of the article or from the outside, all variously contrived, but in such a manner in each as to insure and maintain perfect concentricity; the greater number of them are in advance of anything that was shown at Vienna, whether considered in regard to efficiency or in simplicity and adaptation for permanent truth; or, again, in the matter of screwing taps, there were none to be seen at Vienna equal to the foremost of the English type, nor yet in advance of those originally made by Whitworth or Sellers. There are taps in England with all the improvements of those houses, yet with something in addition by which the friction of such articles when in use is reduced to minimum. This system originated with Mr. Wilson of Patricroft, and is now becoming widespread. The best [illegible]ps of the ordinary sorts are so made that in the per[illegible]nce of their screwing function they necessarily involve

friction. Of this sort many were shown, but none were exhibited from England of the improved construction which obviates that disadvantage of friction by making them larger in diameter at the small end in the first instance, and then shaving them down in order to find an entrance; by so doing the remainder of the portion of thread upon the tap must necessarily cut a wider groove than that which follows, and hence there is no rubbing upon the interior of the nut, each tooth of the tap acting as a cutter to deepen but not to widen the spiral groove. On the other hand there were some lathes shown for turning taps (in advance of any that the writer has seen in England), in which the slide rest had a camb motion to give the proper three-grooved contour to the tap and avoid the necessity for cutting out the grooves afterwards by more expensive instruments. In regard to drills it must be confessed that America still takes the lead, but other nations are following. It is, however, surprising to find that England has made but slow progress in this direction; this is no doubt due to the want of education, for the screwed drill has only reached us by official reports and similar means, which do not fasten on the minds of the majority of our workmen. The time has arrived when the common drill should be banished except for the roughest purposes; at the best it is only a scraper, continually altering in diameter and presenting no guide to lead the instrument; and from the manner in which these drills are usually ground there is seldom truth in them; whereas, the properly made twisted drill is a positive cutter; it presents a conducting surface, maintains its diameter to the end, and when ground in a mechanical holder (as in the manner shown by Sellers) the angle surfaces are absolutely true.

The shape given to cutting tools or instruments, in order to afford strength with penetration, shows the skill of turners more than anything; in this respect we were not equalled, except in cases where the instruments form part of a system, as for example in the cutting tools for lathes on the method of a holder for a piece of round steel, as re-introduced in modern times by Smith and Coventry, of Manchester, which is becoming general on the Continent although it was only exhibited eleven years ago. The more recently re-adopted English system of forcing water either through the instrument or otherwise with force against the cutting part of the tool did not appear to be shown by any country, although neither the tool-holder nor the water forcing system are real novelties, because fifty

years ago both appliances were used in a lathe for turning and fluting the rollers for spinning machinery in the north of Scotland.

In regard to the details of machines for shaping irregular figures in wood or metal the Exhibition was comparatively barren. America had a few devices which were very good, but still they were mostly of the common type. There are hundreds of these contrivances for copying, both in England and America, considerably in advance of any that were exhibited, for there was nothing to compare with some of the details of the gun-stock machinery of either Enfield, or Springfield, U.S.

With respect to punching, England did not shine at Vienna; our machines were good and probably the best, but in those set to work (whether due to the immediate instruments or to the quality of the iron employed) the holes formed were anything but satisfactory, which is inexcusable.

Comparatively little was shown in drifting by any country, the American system of pushing the drift is an advance upon the old English method of driving, but the more recent system of pulling, which originated in Birmingham, is by far the best of any, and is next to perfection, because it deals so gently with the drifts and makes a perfect hole of any depth or section, and is rendered perfectly under control by the succession of one drift after another; but we did not show any of these treasures, in fact we do not seem to prize them although such trifles are the wealth of our country.

Those who have watched for the past half century the gradual changes in the apparently simple matter of the grindstone, and who know whence the successive changes for the better came, were much interested in observing that the system of grinding upon the side of the stone is now becoming general upon the Continent, and likewise that the mode of holding the grindstone between plates gripped by a screw is the common arrangement; showing that there must be a great amount of intercourse between the workmen of other nations and our own workshops. M. Schmaltz, of Offenbach, exhibited a simple arrangement for the fine sharpening of wood-planing instruments. A flat disc on the upper end of a vertical spindle revolves at the proper speed, the disc is smeared with oil and fine emery, and the edge of the instrument, of whatever length it may be, is held at the proper angle upon the flat surface, and the result is most satisfactory.

Almost every country now sharpen their saws by the

solid emery or composition wheel instead of by the file, but, strange to say, the grinder is mostly guided by the hand; the use of a template from which to copy truth was, however, shown in one instance, and it will no doubt become general, the advantage being obvious. Circular saws ought to be quite true, although they are more frequently otherwise, every tooth ought to be considered as a chisel, which has to take an independent slice upon its own account, in the same manner that a straight saw is supposed to do, hence it is necessary to have the means of sharpening the circular class of saws in a way that will afford the true conditions.

The relative standing of different machine-making nations is affected by all such trifling detail appliances as those here referred to; they all help to determine efficiency or the opposite; and were our knowledge sufficiently precise there would be little difficulty in forming a moderately correct estimate of the state of mechanical affairs in a country, just as it is when going into a workshop on seeing a grinding stone out of truth, or lathes working at a wrong speed, an experienced eye can detect at once that there is a screw loose in the economical management of the factory, however seemingly grand the machinery construction may be, and it is not only so with the trifles referred to, but it applies even to the individual machines, an expert can thereby judge whether there is the real "grit" in the attendants or otherwise. A good illustration in this respect was afforded by the manner in which different nations set their wood-working machinery in motion. Those English houses which brought their own workmen showed advantageously beside those which employed strange workmen of the country, and still more conspicuous was the determined spirit manifested by all the British exhibitors to compel their machines to do their best; they urged each machine to its very utmost capability regardless of consequences, and thereby produced a decided impression in their favour, and with the exception of the saws, as before mentioned, the quantity of work done in a given time would be difficult to surpass. The teeth of our vertical saws did not seem adapted for the particular sorts of timber, and therefore did not cut with sufficient incision at each stroke, each tooth did not get its full share of duty, hence it was more the ordinary cutting than the "do or die" of the other machines, and was scarcely equal to those of either Pfaff or Topham, to be seen in some of the private works at Vienna; this question of the teeth of saws re-

quires investigation by those whom it may concern. Still the working of the machines, as depending upon the staff, was an example to the whole Exhibition in that class, and it certainly produced the effect of rousing others to dare doing the same; but that is a virtue which is not to be acquired in one day.

Still more interesting was the comparative working of the steam hammers. The larger hammers as a rule were not worked, on account of shaking the building, but the smaller sizes had an opportunity of showing what they could do. Most of the machine-making countries had sent hammers to Vienna. Among the rest, England had several of the best descriptions, which for the size were as good as any if not better, but in the matter of working them we were far ahead. There was generally a sort of timidity in allowing the hammer to do its utmost. At the first even England showed a trace of shyness, until the Yorkshire spirit was fully roused. It then made the hammer descend with full force frequently on the bare anvil, with 60 lbs. of steam above the piston in addition to gravity, with blow after blow in rapid succession, which made the welkin ring and the surrounding building quiver to its foundation, to the intense delight of every one, and more particularly to the onlookers from the old country. Such daring confidence showed that the general soundness of the whole apparatus was equal to its work, and more especially that the hammer and anvil faces were made for real business. Those important parts were indeed thoroughly genuine; had they been made of cast-iron, as is frequently the case, it would have been necessary to use a thick piece of wood, or a piece of lead or hot iron in order to save them from injury.

The great treat, however, was to observe the man who manipulated the hammer; the stern expression, and the attitude of a Cyclops, his teeth clenched, and seeming fully conscious that the honour of his country depended upon him for the time being; and it was impossible to resist a momentary feeling of pride from the knowledge that we have nothing to fear as a nation if only we are true to ourselves.

Let us therefore ask what is our duty as a nation in respect to future Exhibitions so far as machine makers are concerned? Are we to hold back or to press forward? If the former, then we may possibly retain our inventions for a few years longer; but the widespread diffusion of our engineering newspapers and other journals on the Continent will afford to those who are inclined to copy the opportunity to do so, while at the same time the foreign

publications do not permeate amongst our workmen in the same manner as those of England do in other countries, partly owing no doubt to the circumstance that in this country we are not, as a rule, acquainted with foreign languages to the same extent as foreigners are with English, and besides there is not that intellectual activity amongst our workmen at the present time which exists in Germany. It would therefore appear that if we are to adopt the holding back policy we shall lose our vitality, and cease to occupy the position which is now accorded to England. If, on the other hand, our motto is "forward," then we must be prepared to have our good designs copied almost as fast as we produce them; but we shall be the first in the field, and by skilful policy will have saturated the markets within our reach before the Exhibition year comes round. Presuming that, as a people, our inventive power is inherent, and that in the future we shall continue to maintain our past character in that respect, and keeping in mind that the field of invention is boundless, that every new device is a fresh centre, radiating in every direction and leading to other contrivances, it would appear, when properly considered and balanced, that our prosperity will be most advanced by the more liberal policy, even at the risk of having to sacrifice and forget the past, and to subject ourselves to the arduous toil of ever pressing onwards to the improved mechanism of the future. This at least will prevent us from settling down in the shade, and from being mentioned in history as the great nation that *once* took the lead in machinery construction.

In the second part of this report reference is made more pointedly to some of the various articles shewn by a few of the leading exhibitors of different countries, chiefly with the object of indicating the good features which presented themselves in regard to progress, merit, or otherwise, and any adverse remarks that may be made are not due to an ill-natured spirit, but rather the contrary, and solely with the view to our own improvement by inference from the lesson which they severally teach.

America.

In thus referring to some of the noteworthy specimens shewn by different nations, it is convenient to take them

in the order which they occupied in the building, commencing with America, which was met with on entering. This position was surrounded both with advantages and disadvantages, the former chiefly due to its securing the first attention of visitors, the latter, from its exposure to the weather, whereby the more delicate machinery was sometimes considerably affected when the wind or rain was excessive.

One of the most striking inventions of modern times is Tilghman's sand blast process as exhibited at Vienna, which, from its novelty commanded much attention and admiration. The disintegration of surfaces by a current of sand or other fine sharp powder is one of the latest discoveries in connexion with tools, and opens up an entirely new field for its application; the remarkable effect produced is based upon the fact that when glass, stone, or other hard substance is subject to the impact of a blast of sand the detrition of the surface is rapidly effected. The fact has been observed for a long time that windows exposed to the drift of sand by the sea shore were gradually affected, until at length they could not be seen through; Mr. Tilghman has turned the idea to practical account, and with a large measure of success. At present, the process is chiefly employed to engrave devices upon plain or coloured glass, which it executes both with precision and sharpness of outline. Although the sand acts so efficiently upon hard substances, still it has little effect upon soft or elastic materials, advantage is therefore taken of this circumstance to make the pattern of india-rubber, lace, and such like, which is spread over and gummed to the surface to be engraved, the blast of sand is then brought to bear across the pattern, and the whole of the bare surface is disintegrated, the depth depending upon the length of time to which it has been exposed to the blast; when hard surfaces are to be engraved to a considerable depth it is found that the requisite velocity of sand current is most easily obtained by the substitution of high pressure steam for the blast of air, steam pressure equal to 50 lbs. on the square inch is employed; in using the air blast the pressure seldom exceeds one pound, and for fine work it is usually much less. If this process is found to fulfil all that is expected, we shall find it applied in many other directions, fluting stone columns, and finishing the carvings that are now made in granite and other descriptions of stone, because the sand blast is applicable for the lathe, the planing and shaping machines, or wherever a steel instrument may be applied. Fortunately the idea

has been developed at a most opportune time when the world is waiting for it, and hence its introduction is not likely to meet with any formidable opposition.

The finest collection from America was that of Messrs. Sellers & Co. of Philadelphia, which had perhaps the largest share of attention of any in the American department. Besides the machines that were shewn in Paris by this firm they had in addition several fresh devices of great interest. Their greatest novelty in tools was a small machine or implement for sharpening drills; this operation is usually accomplished in workshops by the workman holding the end of the drill against the side or periphery of a grinding stone at the proper angle, the correctness of the operation depending entirely upon the man who manipulates the drill, and the consequence is, that comparatively few drills run correctly when inserted in the drill spindle, being generally found to wabble at the centre point more or less, hence unless great care is employed, there is no certainty of precision in the hole to be drilled either as to position or dimensions, but in Sellers' drill sharpening machine, the drill fits into a socket of the same shape as the machine spindle, which is placed in relation to the emery wheel at the proper angle, and then passes under the revolving emery, first upon one side and then upon the other, and thus the drill is made perfectly correct for its purpose. The introduction of the emery wheel instead of the stone, combined with the mechanism, is a great improvement, and the same principle will be found many times repeated in the more advanced portions of the Exhibition, more especially in France and Sweden. This system of grinding was introduced into England from America in 1854, and has been extensively employed at Enfield for sharpening circular cutters, but from some cause it does not find its way so rapidly into our general workshops as might be expected.

This firm again displayed their wheel cutting machine, which cuts the teeth of wheels up to four feet in diameter and is perfectly automaton when once set to work, by this means it is said that one man can attend to the working of four machines, his office being simply to put in the blank wheels and take them out when finished as cut wheels. Looking at this machine as a mere combination of mechanical refinement it was, as a workshop tool, unique, and received great and corresponding admiration. Their lathe likewise was almost perfect, the spindle seemed to float on a fluid, yet it was perfectly steady, and in working had not any of the jerking feeling that is usually to be

found in the second class lathes. The self-acting motion is obtained from the main gearing by means of a disc working between two discs on another spindle, but both on the same axis, hence as the intermediate disc is nearer to or farther from the centre of motion so is the rate of motion that it receives. It is impossible to resist the conclusion that Messrs. Sellers were the most speculative tool makers in the exhibition, and everything that they showed was almost above criticism; their bolt screwing machine is now so well known in England (being made by Sharp, Stewart, & Co.) that scarcely any word of praise or even description is required, but still the one shown at Vienna was a marvel of excellence, the fitting of the dies was perfection, yet withal so plain and simple, so free from every attempt at ornament, and yet so harmonious in its repose and in the full assurance of fitness for its purpose. Their planing machine has been much admired on account of the smoothness of its action, the rack being worked by means of a worm or screw upon the end of an oblique shaft, by this arrangement the driving gear is removed from the end of the bed and placed at the side, thus securing two important advantages by simple means. Their slotting machine is somewhat peculiar, inasmuch as the sliding bar does not slide in the frame as is usual, but works in an intermediate slide rest, thus giving facility either to lower or raise the intermediate frame to suit the work, in order to have the sliding bar which carries the instrument under equally good conditions at all times and thus give extra steadiness. A trifling feature in their tools is, that the sliding bars of their countershaft arrangements are made of wood, they seem to answer the purpose as well as iron, and are of course both cheaper and lighter to manipulate.

A most remarkable article in the exhibit of this firm was a rotary puddling machine, in which the puddling vessel stands at right angles to a gas furnace; the flame enters and leaves the vessel through one opening, passes from the side of the furnace through an opening upon one level, and after striking upon the liquid or viscous metal and doing its work it returns through the puddler to a lower opening in the under part of the furnace and thereby finds its way onward to the chimney. The puddling vessel in shape resembles a large Carron pot, with the mouth smaller in diameter than the interior; this vessel is placed upon its side and mounted on rollers, in order that it may revolve freely, in one respect it differs from the pot inasmuch as the bottom is hollow and filled with water, so as to protect

that part from the effect of the intense flame to which it will there be exposed when in action as a puddler. The vessel is lined with oxide of iron or other suitable material, and worked by an independent steam engine, which at the word of command is made to turn round in either direction, or when required, the puddling vessel will take any number of steps on the left backward wheel, thus giving free admission for the attendants to examine the interior, and with equal readiness it again closes up to the side of the furnace; the whole of these movements were performed, and in the entire exhibition perhaps there was not a more important novelty shown than this puddler, and the general opinion was that a great future lies before it.

The writer of this report however does not give his full concurrence to this unqualified approbation without further evidence of the practical working of the apparatus in the forge, fully admitting that it is a most ingenious and beautiful contrivance so far as regards its mechanism for the intended purpose, still it would yet seem to be peculiarly exposed to many contingencies in working it as an iron making furnace, and hence it must not only be considered as a mere tool or machine like a lathe, but as a machine which will necessarily be exposed to an intense heat that will probably affect its working efficiency when considered merely as a machine, the cast iron hollow vessel will be liable to warp and get out of form, and thus become unfit to turn round freely, or by the carelessness of the fettler when lining it from time to time, it may have a hole burned through the side at any moment, the fact that it is made of cast-iron would alone seem to open up a list of contingencies to which it is necessarily exposed from hour to hour; had it been constructed as an annular vessel, and the sides filled with a continuous circulation of cold water similar to the bottom, the chances of success would have been more evident, besides it is difficult to see how the face of the furnace against which it will have to rub is to be maintained in its integrity, the hope of luting with clay is inadmissible, and doubtless the slag will find its way to the vicinity of the joint and occasionally clog the movement, thus causing it to stick fast, rendering it necessary to use a crow-bar with force to disengage the vessel from the face of the furnace, and incurring great risk of fracturing the delicate mechanism as the stick-fast condition approaches, and in addition it is a very expensive arrangement having to compete with others more simple. Of course the puddler could not be worked in the exhibition building, but it was supplied with

steam so that it could go through all its paces, this it did in the most perfect manner, and great interest was excited in regard to its future behaviour when set to work for its living as an iron-puddler.

This house had, likewise, a very perfect and carefully considered Nasmyth hammer, in which, by a simple arrangement of a loosely-fitting circular valve they control the resistance of exhaust in order to moderate the blow; they likewise showed a particularly simple method of fixing the removable portion containing the face of the hammer to the hammer proper, all being done by boring and turning and by the agency of an intermediate annular wedge in halves, the whole secured by a side wedge; by this system, and with the aid of a wooden mallet, a change is made with but little trouble, and the security is certain.

From the foregoing short description it will be seen how rich this house is in mechanical resources; to do them full justice would occupy more space than is occupied by the entire report. This is a pattern house for machine-tool makers to study, at every exhibition it brings forth things new and old, and as a rule all thoroughly well considered even in the most minute detail so far as mechanism is concerned, more so than many firms which adhere to the most hackneyed description of the ordinary sorts of tools, and continue to make them from year to year without regard to improvement; and it was a source of satisfaction to observe the extreme interest with which our young men lingered around the exhibit of Sellers and Co., admiring the good points and keenly discussing the merits of the puddling machine from the iron-maker's point of view.

There is an extensive manufacture in America of a small class of machine tools quite characteristic of the country, and thoroughly distinct from the machines of any other nation used for the same purposes, although other nations are now adopting them by slow degrees. These American machines are distinguished by great refinement in the workmanship, but as a rule without much design in the arrangement. In 1851 this country first became alive to the fact when Colonel Colt set up his factory at Pimlico, and in 1854 the writer brought over from America an immense variety of such machines for all sorts of purposes, more especially for the Enfield factory of small-arms. In the Vienna Exhibition the American houses came out strongly with an extensive variety of such tools intended for all purposes in connexion with the manufacture of sewing machines, of small-arms, and for producing the

finest class of instruments of every kind, such as circular cutters, twisted drills, steel squares, and other things innumerable. Two houses in particular had each a grand display, namely, Pratt and Whitney, of Hartford, U.S., and Brown and Sharpe, of Providence, U.S.; it is difficult to say which had the best products, both were first class in all essential particulars, the workmanship was a treat to look upon, and the liberality with which these houses distributed their books and photographs showed that they were not afraid of competition.

For some reason English tool makers as a rule do not go in for the particular refinement that lies at the root of the American system, more especially in tracing out the intricate figure from a copy, partly by the shape of the instrument, and partly by some modification of the figure having to be passed over, either by the instrument or by the holder containing the piece of metal to be operated upon, as in bridge-milling. A study of this system opens up a wide avenue leading in all directions; our lathes, planing machines, and other tools in great measure restrict our forms to circles, curves, straight lines or cones, and a few other forms, within which, in the production of the heavier class of machinery, men strive to bridle their wants; but the American system of tools gives a greater latitude, as for example, in producing the constituent parts of the lock of a musket, each of which is formed and left by the tools so accurately as to make the parts of the musket really interchangeable, even to the hundredth of an inch in every dimension, and with these contrivances neither the form nor the dimensions are dependent upon the immediate attendant; our young men should study this system, because it offers a fine field of usefulness to those who are patient and ingenious. It was observed at Vienna that both Sweden and Germany are alive to the system, and made a fair display of some of the more common articles of the lathe and milling class; it is only when customers are refined in their notions and requirements that the more recondite machines of the American type are in demand.

The special novelties of Pratt and Whitney were more conspicuous in the adjustable holders of articles, their contrivances for sharpening intricate cutters by the solid emery wheel, by using an index to show the depth of penetration of drills, and in the admirable manner of making small screws, every tool being permanently fixed. Their screw-making machine takes the rod of iron or steel, divides it into length for the required screw, turns, points, and screws

it, and delivers it ready for the slit. In screwing, it is so arranged that on touching a stop it reverses itself, runs back, and brings up the steel rod for the next screw. Similar ingenuity is introduced into their drills, where the hole has to be of a definite depth, an index is previously set correctly, which, when it touches a stop, causes the drill to draw out of the hole. Their machine for copying irregular forms performs its duty neatly and with precision. The same may be said of their drill machines containing several spindles, with a different drill for each of the various holes or countersinks in the article under operation.

The other firm of Brown and Sharpe had a perfect universal milling machine, capable of performing at any angle or direction; such a machine is an invaluable adjunct to any workshop, but except in the War Department this class of machine is rarely to be seen in our English factories, why, it is impossible to say. This house had likewise some very cleverly devised small tools for their machines; one especially was much admired, it was employed for cutting a screw thread close up to a shoulder and then to stop dead, certainly a delicate and difficult operation; it was a sort of chuck consisting of two parts, the one sliding within the other, when in use the revolving head moves forward until it is stopped by a pin, then the inner part holding the die advances by the screw, which it cuts until it unlocks from the outer piece, and then merely revolves, the spindle motion is then reversed, and the apparatus is drawn back by hand. There were also shown most ingenious workshop tools for slitting the heads of screws, for sharpening cutters of any description, and for other purposes; this collection was very rich in such ingenious devices, and was a very good place for every one to have any lurking conceit taken out of them in a most pleasant manner.

Jones and Laughlin of Pittsburg, made a strong impression upon the minds of European engineers with their cold rolled shafting. It will be remembered that this invention occupied a good deal of attention in this country in 1859, when experiments were carried out by Sir William Fairbairn, which gave a good result in all respects and improved the quality of material both in regard to strength and stiffness as well as in accuracy in parallelism and roundness. During the interval, the invention has been assuming more and more importance in consequence of the growing price of labour, until at length the time seems to have arrived when this cold rolled shafting will find its way into general use, not only for shafting, but for every class of

articles that are straight and parallel, and of whatever section. In the machinery of the textile manufactures a wide field lies open for the production of such articles as are now finished by the lathe or planing machine; besides there are likewise a great variety of articles made out of plate iron where the improvement due to the condensation and smoothness will be of immense value, for such articles as spades and the like, that have to be strong, the increase of strength due to the cold rolling in some cases was nearly equal to 100 per cent. and seldom under 50 per cent. This therefore is an invention that bids fair to make quite a revolution in the mode of arriving at the classes of articles above referred to, and will in time tend to the reduction of cost. A general summary of the results of experiments made in England, at the works of Nasmyth & Co., by Sir Wm. Fairbairn, is shown as under:

Condition of Bar.	Breaking stress per square inch.		Strength (the untouched Bar being unity.)
	In lbs.	In tons.	
Iron in black condition untouched.	58,628	26·173	1·000
Rolled cold by this process.	88,230	39·388	1·505
When turned in a lathe	60,746	27·119	1·036

Samuel A. Miller, of Cincinnati, exhibited one of the rudest pieces of mechanism that could be imagined, one of the kind of things that Robinson Crusoe would have made for his own convenience, it was placed in an out of the way corner as though it was of no account, but yet it was a gem of the first order; this machine was said to be for making stove elbows, that is to say, a sheet of thin iron or tin plate was given to the machine, which by its mechanism converted it into a pipe and then bent the pipe into an elbow of fine curve and at right angles. To those who are familiar with the displacement of material, or gusseting, that is involved in bending such a thin pipe of sheet iron, the necessary withdrawal of the metal from the inside of the bend, the disposal of that surplus, and the formation of a perfectly curved bend which would take a skilled man hours to accomplish, will readily see that it is a great feat

to achieve; this machine by a few turns of a handle, takes the plate, folds it into a tube, bends it, and crimps the folds of the inside into an uniform series of neatly laid gussets. This apparatus, although a rough diamond at the present time, has a future before it; Mr. Miller must however put the construction of his machines into other hands, because in addition to his mechanical genius it requires the constructive art knowledge, which other men have been accumulating for hundreds of years.

Thomas Hall, of Northampton, Mass., exhibited a most admirable vice, which, in the opinion of all, was said to be the best yet seen. In construction it was parallel in its movement, but its chief feature was that it could be adjusted instantly and by one gentle motion; it is placed upon an automatic swivel, and is so arranged that the grip of the vice likewise holds it fast in any position in relation to the bench. The gripping power is actuated by a short lever placed in front, and when the grip is relieved the vice may then be drawn back with the other hand, the article inserted and then pushed up to grip, when the mere depression of the lever is at once sufficient to make all fast as a rock. From the circumstance that in outward appearance this vice resembled the eccentric vice with which we are all more or less familiar, the general impression was that it belonged to that order, but as the eccentric movement would not explain some of its peculiarities, a good deal of conjecture was bestowed upon its principle of action. As the proprietors did not at first seem disposed to show its interior to the public, in order to protect themselves for the present, this mystery added considerably to the interest, until at length they disclosed the secret, namely that the motion was the old toggle joint, certainly a most ingenious idea, and one which is most perfect in its action for this sort of purpose. All who know the action of the toggle are aware, that as it approaches to the straight line, the power is next to infinity, because it then produces scarcely any motion, while the friction at the points of movement of the toggle are almost nil. This vice is practically so good that it commended itself at once, and is sure to be taken up in England very shortly, and unless it has some unseen defect will yet become an important addition to our labour-saving appliances in the workshop. Now that the toggle has been applied to this particular purpose, all are wondering that no one thought of it before, but so it is, in all our books which treat of this contrivance the merits of the toggle are descanted upon, the Stanhope

lever is delineated and its infinite power at a particular point is demonstrated and shown to be the instrument most suitable wherever intense pressure is required with little motion; with almost everything else it is the same, the devices of the future are staring us in the face but we do not see them, until one after another they are thus turned to good account by some man more clear-headed than his neighbours.

Stiles & Parker Press Co. exhibited a power hammer worked by straps, which is a very convenient machine for situations where steam is not to be readily obtained, but otherwise there is not much to be said on its behalf. This firm likewise exhibited some good machines for stamping, cutting out, or forging metal; the chief and perhaps the most notable point in connexion with them was in the mechanism for adjusting, coining or other dies, punches, or any other tool. In die working it is especially of consequence, that the surfaces may be adjusted even to a line of the thousandth part of an inch, which was here accomplished by the introduction of an eccentric into the structure of the connecting rod, and by a slight movement adjusted the relative surfaces with the utmost nicety, yet without changing the distance that the connecting rod will travel. This is accomplished by having introduced between the crank pin and the hole in the connecting rod an eccentric ring, with teeth cut upon its exterior for a worm, and having the worm fitted into the extremity of the connecting rod, with a handle by which it can be regulated in its length with the utmost nicety, as in the case of a punch, as the point is ground away the lengthening of the rod makes good the deficiency, all such trifles indicate great refinement, both in the conception of the idea and in practical working.

The firm of Darling Brown & Sharpe had a good collection of the class and sorts of tools for which Holtzapffel of London was long so celebrated, these tools were mostly small, circular cutters, gauges, steel squares, callipers, measuring instruments, &c., all of the first class in regard to accuracy and workmanship, and modern in regard to style and adaptation.

Morse Twist Drill Co., of New Bedford, Mass. It may seem superfluous to notice the display of this firm, because they have been already referred to in the general part of this report, but it is necessary to do so because a great number of our workshops are still using the old drill; why this should be the case it is impossible to say, the old

drill is a rude contrivance only suited for a rude age, besides, it does not cut in the true sense, it merely scrapes by sheer pressure. These twisted drills of the Morse Company are real cutters and bring out shavings which are worked out of the hole by the configuration of the drill. The display here made was a treat to examine: the drills were of all sizes, from that of a needle up to two inches in diameter, and they are largely manufactured, both for American use, and for exportation all over the world, neatly arranged in cases like the Whitworth screwing implements. Even this careful treatment of the drills has a prefining influence, drills are usually treated in a very different manner from taps and dies, but this ought not to be the case, and we shall do wisely to take a leaf out of the American book in respect to this really important matter.

A remarkable machine for compressing iron tires upon the periphery of ordinary wooden carriage wheels was exhibited by James Barnes West, United States, and is well worth the attention of all who are interested in such articles. The usual method is to make the tire smaller than the wheel, then to expand it by heat, and when sufficiently enlarged to slip it over the wood, and by instantly immersing the wheel structure in water to prevent charring of the wooden felloes, the tire cools and contracts. With Mr. West's machine the iron tire is forged sufficiently large to slip over the wheel in the first instance, it is then put into the embrace of this machine, which so acts upon it all round the circle that the iron is thereby constrained to upset into itself by a positive shortening of the ring without crumpling, and thus to grip the wooden wheel. The mechanical arrangements employed to effect this object are extremely simple; they consist of a band or bands of steel or iron, made to form a true circle, one end of the steel band is a fixture and is cut or fined away in such a manner as to admit of the loose end of the band going past it tangentially, the loose end of the steel band terminates in a powerful screw with spur gear, the power is applied in the usual manner, thus reducing the circle and drawing in the band around the wheel, consequently a short hug is sufficient to produce the desired effect; the diameter was reduced one inch in less than a minute. Doubts were expressed in regard to the permanence of the effect, suggesting that the upset of the iron would relax in time and return to the original condition, but we have no warrant from our experience with other things, to antici-

pate such a result. From the amount of interest which this machine excited amongst European exhibitors, and from the satisfactory manner in which it performed its office, it is probably one of the notabilities which will date back to the Vienna Exhibition; some of the British houses have already arranged with Mr. West for its manufacture in this country.

An interesting collection of pail or tub making machinery was exhibited in operation by Baxter D. Whitney; this class of machinery originated in America at least a quarter of a century ago, and has been greatly refined by the exhibitor. In this manufacture the wood is first sawn up into planks the breadth of the staves, then cut into pieces of the proper length, these are again sliced into staves by a sheet cylindrical saw with the teeth formed upon its extremity, the staves are now baked in an oven, then have the edges planed by a suitable machine to the required form, the pail is set up with a temporary hoop and slipped upon a conical cnuck, there held by an end washer-plate and bolt, and the hoop removed. A slide-rest tool is then passed along the exterior surface, the temporary hoop is again applied, and then pushed into a box chuck, another slide-rest tool is passed down the interior and finishes at one move. When at the bottom, the workman with the left hand in an instant moves another chisel to form the groove for receiving the bottom of the pail and finishes the upper edge. The boards for the bottom are planed on both sides in the ordinary sort of machine, then sawn into squares, the squares are gripped between revolving plates and cut to the proper diameter by a parting tool, when a second tool bevels the edge to fit the pail, the time occupied for the entire operation being about five minutes. All the machines are specially made for their particular task, and it does one's heart good to see people going about their work in such a purpose-like manner.

Another machine, for scraping wood, was shown by this firm. In the application of machinery to plane wood, although we may congratulate ourselves on the rapidity, the general correctness, and especially in the cheapness of our productions, still there is a latent feeling that we are far from perfect, that we cannot equal the finished products of the best cabinet work. In the American section a machine was shown in operation that not only equalled but surpassed the finest hand planing. The sorts of wood acted upon were hard, and chiefly of the fancy kinds employed in cabinet work; the action of this machine was more of a

scraping process than strictly planing, although it brought off a shaving like a sheet of tissue paper the entire size of the board, which it made as flat and smooth as a mathematical surface. In ordinary cabinet work it is rare to see a mathematically true surface, the French varnish and a proper light shows the offensive uneven surface most conspicuously; as before said, this machine employed a scraper which consisted of a thin blade of tempered steel, which was held in the machine by a suitable fixing, and in order to sharpen it had an emery wheel passed over its scraping edge, the wheel being guided in a slide-rest, thus the edge of the scraper was straight in the strictest sense. The board to be scraped had been previously planed carefully by a planing machine of the ordinary sort, it was then placed in the scraping machine which consisted of a series of carefully prepared parallel rollers, top and bottom, the board being inserted between, a slow motion was given to the rollers, and the board then passed through (as solid as a rock) under the firmly held scraper. At the first passage, or perhaps the second, and sometimes even the third, the shaving removed was not quite perfect, any defect in the shaving was an index of the imperfect surface of the board; at length it was absolutely perfect, the shaving being a transparent sheet of veneer. It will thus be seen that the essential conditions are simple and attainable in different ways, the chief point is to get hold of the idea, the end of the clue will in time lead in many directions.

The same American collection contained a species of lathe for turning articles of wood which have to be frequently repeated such as ornamental stair balusters, the legs of tables or chairs, bed-posts, and such like. To turn the leg of a mahogany dining table by the usual hand system is both tedious and expensive, it will take a good workman at least an hour to make it in accordance with the pattern, and even then it will not be exact in every particular. In this lathe, the piece of wood is introduced and is removed a finished article within one minute, and all to pattern. To cabinet makers who are not acquainted with what the rest of the world are doing with such machinery this may seem a marvellous feat, but there are many more wonderful things of the same kind in our own country and yet after all there is no magic, there is first the common lathe, between the head-stocks a sliding frame is arranged and fixed to suit the dimensions, this slide contains two instruments or knives, both the entire length of the article, the one knife to rough out nearly to size in advance of the one

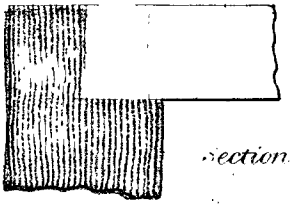
to finish, both are set on the skew in order to take the work in detail, the first blade is merely to bring the piece of wood approximately to form, while the other blade is cut out exactly to pattern with all the irregularities of the required table leg, and one single passage of the slide with its two instruments in moving past the revolving article is all that is necessary, the greater part of the minute being occupied in putting in and removing. It is only by the introduction of such machines for every kind of work that the world will be able to progress in these days, we require things to be good and beautiful, at the same time not expensive. For house builders who employ round ornamental balusters, such a machine would be invaluable. Altogether this entire collection was rich in original ideas for attaining high class productions at the minimum of cost, and it deserved careful study.

For the past 20 years the attention of machine makers has been directed to the production of a machine which should perform the work of dovetailing as neatly and securely as that of the skilful cabinet maker, many of the attempts were very ingenious but none were entirely satisfactory until 1867. The first few months of the Paris Exhibition had run their course, when at last there appeared an American machine which took the machine making world by surprise; it was the invention of Mr. Samuel Thomas Armstrong of New York, and the execution of this new machine was so perfect in its action that the leading houses of all countries at once took it up, and a considerable number of the same class were to be found scattered through the Vienna collection. In the Armstrong machine the cutting instruments are of the saw order and are arranged upon an irregular circle, or rather helix, which, as it revolves, cuts out the dovetail spaces in succession with rapidity and considerable accuracy. It not only saws the two sides of the dovetail but it likewise saws or cuts out the pieces at the back, and cuts or saws out between the pins of the dovetail in a similar manner. It is, however, an expensive machine and has to be constructed with care, or otherwise it is unsatisfactory; besides, any given helix saw will only cut one pitch of dovetail, but this it does very cleverly and snips out the piece to form a dovetail or a pin at one entire revolution, and works on by a self-acting movement. Previous to the coming of the Armstrong dovetailing machine there were several approximate sawing machines used for the purpose, rather imperfectly, that contained what was termed a "tipsy saw,"

which, if made to wabble the required amount, would saw out the greater part of a dovetail, but to do so, the saw had to be slightly elliptical in order that the wabble should afford to the cutting edge a true circle which it could not do if made perfectly round. The "tipsy saw" would, however, cut approximately any pitch or width by making it out of truth more or less, and the same for the pins; taking advantage of the foregoing an ingenious dovetailing machine has been constructed in England in which the saw is made "tipsy" by the mechanism, the spindle contains within itself the necessary elements of mechanism that are required to work out the geometry of the motion that is needful in the saw, both for the dovetail and the pin, all correctly to width and angle in every respect.

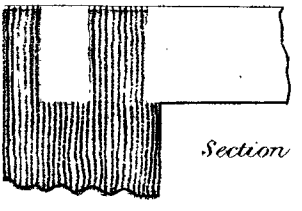
The Vienna Exhibition has brought forth from America another system of new machinery with the same object in view, but upon an entirely different principle of joining the wood and the mode of action. This entirely new device is now shewn by Mr. Knapp of Northampton, Massachusetts, and is called a "dovetailing machine designed especially for cabinet and other fine work," but as the mode of joining has no resemblance to the tail of a dove it will require another designation more in keeping with the system. The accompanying diagram will explain the principle of Mr. Knapp's system, and from which it will be seen that in one of the pieces a portion is removed by revolving hollow spindles, thus leaving pins on the solid wood; the other piece is correspondingly cut to shape by revolving cutters combined with a series of drills to form holes for the pins, hence if the tools are correctly combined, as they certainly were in the machine exhibited, then the junction of the two pieces of wood is both strong and perfect.

From the variety of opinion expressed, it is difficult to say whether this system will supersede the old method or not, in either case it opens up to cabinet makers a new field of inquiry, in order to see if even some more simple and less expensive mode of joining may not be devised and effected by a less costly machine than that of Mr. Armstrong. Mr. Knapp's system of tools points in the direction of economy, and much may be done with well directed thought, both to simplify the joint and the mode of forming it. Above all, keeping in mind that wood is not metal, we have no power over its production, it grows and cannot be made, therefore, all our mechanism must be founded upon the character of the particular sort of wood to be



FULL SIZE.

Section at A.B.



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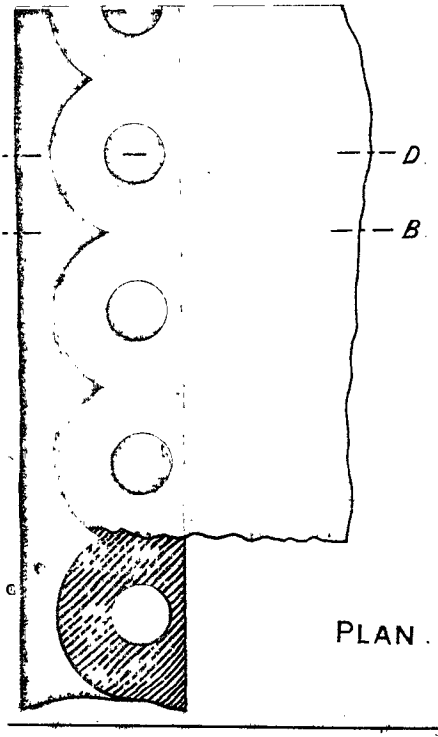
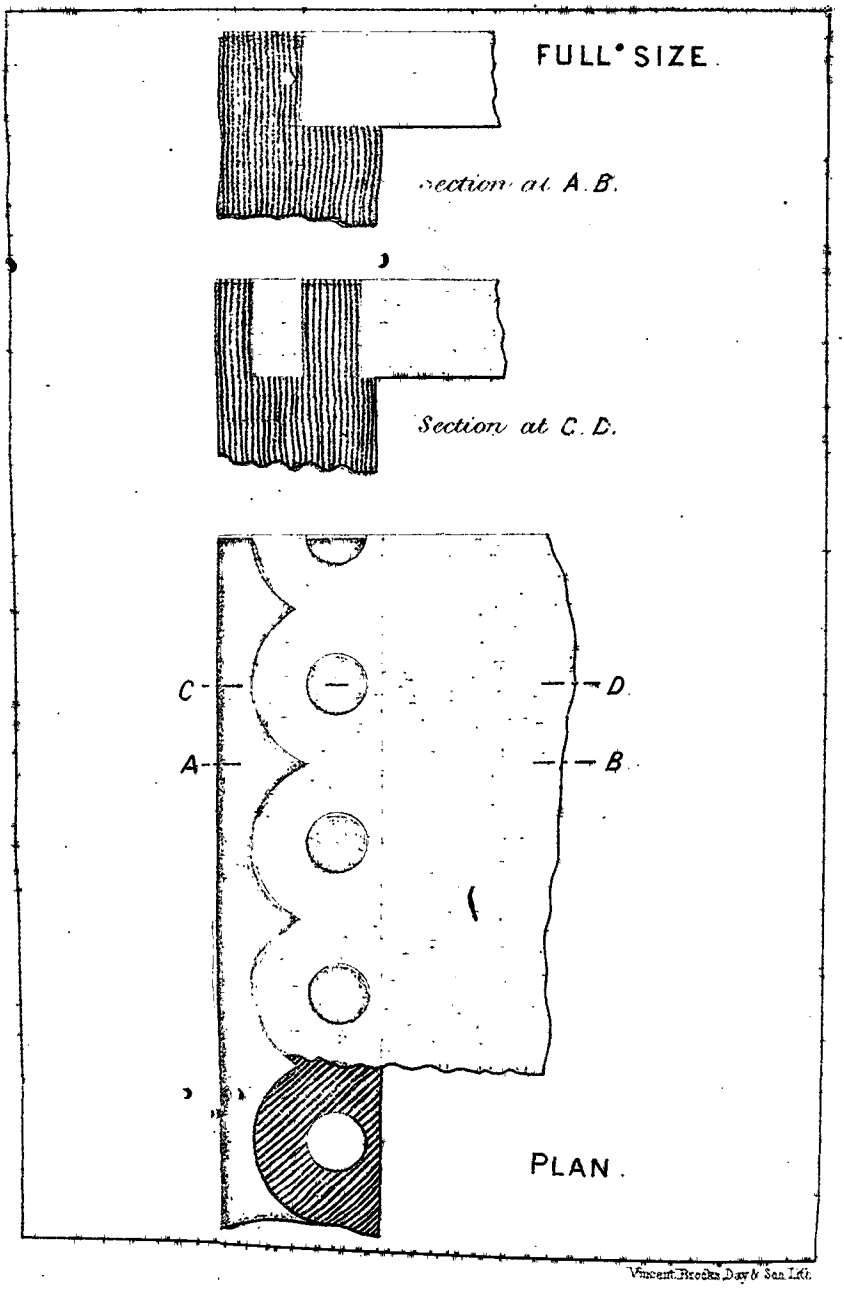


PLAN.

Vincent Brooks Day & Son Lith.


FULL SIZE.
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C
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PLAN.
Vincent Brooks Day & Son Lith.

worked; the hard woods employed by Mr. Knapp were beautifully worked, but it is not certain that the softer woods used in Great Britain could be joined on this system.

An extensive plant of machinery for working wood was exhibited by C. B. Rogers and Co., of Norwich, Connecticut, constructed perhaps rather more in the English than in the American style, but as a whole it wanted character; reference is however here made to it, chiefly on account of a rather good arrangement of the fixings, whereby the instruments which require sharpening could be opened out at once, and without such a great amount of trouble as we frequently see to be involved; it only required the unfastening of a slip-bolt, and then the necessary parts could be moved out of the way upon the left pivot. The "getatable" virtue is too lightly esteemed by many of our machine makers; next to thorough efficiency, this point should have the first consideration. This firm exhibited wood-planing machines of various sizes, but with a good deal of resemblance to our own, some of them rather pretentious in their style of construction, with a partiality for Gothic lines, and a strong trace of the drawing office, although not entirely so; sound practical good sense pervaded the majority of the machines; that some of their cutters, with a diameter of $4\frac{1}{2}$ inches, make 3,800 revolutions per minute is probably the best praise that can be given, and if the parts will submit to such a velocity they must be very good. This house had a good arrangement for sharpening planing knives, the same being fixed at the proper angle upon a holder, which can only be moved in a straight line across the face of the stone, thereby securing a good edge for the knife, and at the same time keeping the stone in good order. A very cleverly arranged machine for the formation of twisted balusters of any pitch or pattern was well worth attention; the piece of wood being first turned into a cylinder by another machine is then pushed through a spindle which gives it the required pitch of screw; at the same time a circular cutter of the proper section running at high speed produces the pattern. They had likewise a good machine for wheel nave morticing, with the necessary screw augur to make an opening, and on a separate spindle was fixed the morticing instrument; there was, however, so little novelty in many of these machines that it is scarcely necessary to notice them in detail, although the whole collection deserved careful inspection.

Several other American houses made a considerable display of wood working machinery, all very good and simple in their arrangements, but there was nothing very original or strikingly conspicuous. One of the ribbon saw machines had a hard steel pin behind the smooth edge of the saw to give it support, and was so arranged that as it became worn by the rubbing it could be turned round to present a fresh bearing surface to the saw, but whether this is better than the simple piece of wood or the steel roller is not easy to say confidently without a trial.

America did not shew much in textile machinery, but what it did send over was of great importance; the most remarkable was a machine invented by Mr. John Avery, of Massachusetts, for spinning short wool or cotton continuously, which was put forward as a substitute for the self-acting mule. The mule has long been celebrated as the most gentle device yet invented for spinning delicate yarn, in which the most conspicuous feature is a carriage containing the spindles that go up to the delivering rollers, gently leads off the thread, and communicates to it a certain amount of twist, which office it performs most admirably. The chief objection to the mule is the great amount of space that it requires on the floor of the factory, in order to give room for the carriage to run backwards and forwards; in this new machine the movement of a carriage is dispensed with, and the space occupied is similar to that of the ordinary throstle spinning frame, consequently, a factory of given dimensions and cost would contain a correspondingly increased quantity of spinning machinery. It would be premature to say whether this machine will realise all the delicate action of the mule, but, judging from the peculiarly gentle manner of treating the fragile thread, and its mode of action, it seemed to many very likely to be successful; there have been already several machines invented that were, in their day, expected to lead in this direction, both the Danforth and the Montgomery cotton spinners were notably so, but the mule up to the present time, for the spinning of soft fine yarn, has successfully held its own, because neither of those machines handled the yarn so delicately or secured the good points of the mule to the same extent as this new competitor. From the circumstance that some of our leading makers of textile machinery were in Vienna, and from the serious manner in which this new device was examined by them, there is no danger of its merits being overlooked, but from its importance, and the great question which it opens, it would be rash to arrive at a hasty con-

clusion. This machine claims to do more and better work with one half the usual number of spindles, at less than one half the expense, and to occupy less than one quarter of the space, that it draws the yarn more evenly, and makes less waste than other machines. In this machine the roves of wool are drawn from a long reel of bobbins in the usual manner, but after a short space has been passed over, the rove in the soft state is held by an exceedingly ingenious reciprocating piece of mechanism, which gently draws out the untwisted portion within its hold, while the released part beyond is being continually twisted and wound into a cope upon a spindle. The mechanism of such an intricate machine as this is can scarcely be made intelligible without a diagram, and this the proprietor very properly withholds until the invention is fully secured by patent; but the most ingenious part is that which handles the rove as before referred to. When the rove leaves the bobbin, two gripping wheels rise and fall from or upon a given centre, thus maintaining an equal distance; the rove is taken hold of by a movable arm in connexion therewith, and pushed against the end of another movable arm (part of the same combination), which holds the rove for a moment until a further movement of the two wheels brings two other arms in contact in the same manner; meanwhile the former arms relax their hold of the rove, and the twist upon the forward portion of the yarn in an instant communicates a small portion of its twist to that which is behind, just sufficient to give the rove strength to hold together as it proceeds onwards to be fully twisted. Judging by the mode of treatment as seen at work, it did not appear to act so gently with softly twisted yarn as does the mule, and most probably it will yet be found limited in its application, except to the stronger sorts of yarn that will submit to the rougher handling which seems inherent in Mr. Avery's continuous wool spinner, but, whatever may be the case, it was impossible not to admire some of the devices that have been introduced to perform such a delicate operation, and it is to be hoped that it will fully realise the inventor's expectations.

For some considerable time past America has been great in boot and shoe making by machinery, while many causes have operated in producing this result, the scarcity of labour and the aptitude of the American machinists for the invention of such labour-saving devices have been the chief propelling influences to lead to their present proficiency. A most interesting collection of machinery, having for its

object the heeling of boots and shoes, was exhibited in operation and attracted special attention from the people of all nations, not only on account of the novelty, but likewise from the perfect manner in which it performed its work. This plant of machinery was exhibited by Horace H. Bigelow, of Worcester, Massachusetts, the principal machines were of three classes; the first machine was for compressing the leather in order to render it hard and firm, but it was done partly from the exterior edges in order to prevent the waste by trimming off, as is customary with shoemakers; it thus made the leather thicker by the quantity of leather that was in the odd corners. The character of the compressing machine will be approximately understood by its being stated that it resembles a slotting machine with a screw arrangement to accommodate the increasing thickness of the heel as piece after piece is introduced into the die. Before the pieces are put into the die, however, they are first compressed upon the edge by being subjected to the action of a movable horizontal jaw or mould, that is actuated by means of a toggle joint, thus bringing them roughly into form for the machine. The great pressure combined with the polished condition of the die has the effect of giving a fine polished appearance to the entire exterior of the heel; while in the die, an instrument charged with awls pierces through the mass, the requisite nails are inserted into the respective holes, and thus it is made ready for the second or attaching machine, which is adapted to receive the boot or shoe, and by the pressure of the machine, with accumulated power from suitable gearing combined with a fly wheel, the heel is firmly attached in an instant. The article then passes to a third machine containing a revolving cylinder with an emery surface at each end, against which the lower part of the heel is pressed in order to polish off the nails and leather, the dust disengaged being carried away by means of a fan within the cylinder. In addition to the foregoing there were a number of contrivances for cutting out soles and heels and for other operations in connexion with the Crispin art. The Americans are manufacturing boots and shoes by the aid of these machines with Chinese labour, and they state that the compresser machine turns out 1,200 pairs per day, and that the attaching machine with two boys produces 60 pairs per hour, but whatever may be the quantity of work performed, the machines certainly execute the work with great rapidity, and the quality apparently equal to the best hand-work. It may seem a

hardship to the shoemaker to introduce machines to supersede his labour, but it is not so in the end, the old trades by the competition of past ages are ground so low that it is rendered desirable to introduce new systems of working, if only to give the operatives a fresh start, because such machines, by their increased production with a given quantity of labour, will really enable higher wages to be paid without increasing the price to the purchaser; but it may at the same time prove a misfortune to those individuals who have not the natural aptitude to fall readily into new methods of working.

One of the most conspicuous novelties which excited general admiration was the Woodbury Brush Making Machine exhibited by H. C. Covert, of New York; the object of the machine was to insert the packets of bristles into suitable holes pierced in the solid wood, a bundle of bristles was given to the machine which carefully assorted them into packets, these were each bound and entwined with a fine brass wire which is cut to length, the hole in the wood was drilled and tapped to form a screw, and the wire binding became the corresponding thread which the machine inserted and screwed home; but the most ingenious part of the contrivance was in connexion with the wire binding, which was so arranged that any attempt to unscrew the binding wire caused it to slacken and open by the effort and thereby catch a firmer grip into the hole formed in the wood. This machine was entirely self-acting and performed its work rapidly, faster than the eye could follow, and the various steps could only be seen by moving the machine slowly. This interesting tool is likely to make its way in the world, it well deserves the attention of brush makers, and it is certain to find its way into England, because the brushes so made are superior to those made by the usual methods.

As might be expected America was well represented in sewing machines by all the leading houses, including Howe the inventor, and these machines as a rule were not surpassed by those from any other country. One in particular, the "Weed sewing machine," is so contrived that the action of the needle can be stopped without incurring the trouble of stopping the general motion, including the treadle. An ingenious machine was shown for splitting leather entirely novel in its action. In apparatus for making soda and mineral waters the Americans were the first at Vienna, the display made by Mr. John Mathews, of New York, of machinery for this purpose was a marvel of inge-

nuity, and the several constructions were splendid in the strictest sense of the word, both in regard to magnitude and polish, every part being beautifully silvered on the surface.

The above-mentioned machines are only a few of the more prominent novelties in the American department, for it was full of riches in other respects, and especially in what may be considered the trifles of workshop appliances, ingenious chucks, friction clutches, modes of holding articles, and other things too numerous to mention in this brief report. It also contained some things which were not so good, and even some of bad design and hasty workmanship, that however is of no useful interest to us, and it is a remarkable feature with the Americans that their defects at one exhibition are generally eliminated before the next takes place.

Great Britain and Ireland.

As at Paris in 1867, so in Vienna, the makers of wood machinery came out nobly, and the display made by the English houses, when considered as a whole, was quite a credit to the country. The fact that five of our best houses were upon the ground, all with samples of their very best specimens, speaks for itself; the entire collection was first class in regard to real goodness for the purpose for which the several machines were specially contrived, and although there was not so much originality as might have been expected or desired, still there was a good deal, and the combined effect was indeed splendid. In referring to the different firms which exhibited, it is embarrassing to criticise freely without making remarks which may seem unfair or invidious, and it is all the more difficult, because the exhibit of each firm was of so high a standard as almost to defy criticism; but the best feature of all and for which each firm was highly to be commended, was the fact, that it was to all appearance a national display, and to the outer world was conducted as such; any rivalry which necessarily must exist at home, was not exposed in presence of our foreign competitors, and the several firms went to Vienna to unite in a friendly competition with other nations, but not with each other.

The display made by A. Ransome & Co. of London was particularly striking, because all their machines were well designed and arranged in regard to proportion, and were characterized throughout by refined workmanship. This

collection embraced vertical saw frames, circular saw benches, band sawing machines, machines for planing, moulding, shaping, recessing, mortising, tenoning, mitreing, a general joiner, and a saw sharpener. Such a number of machines, all of the best description, and kept in the finest order, was indeed a treat to see in action. The planing machine was the one that attracted the most attention on this occasion, from the circumstance that it possessed a novelty, namely, a fan to withdraw the shavings from the interior of the machine, and deposit them in a vault under the floor, a very sensible arrangement and one which ought to be applied to every wood working machine that renders itself offensive to the attendants by the dust and chips which fly about and fill the surrounding atmosphere, and which doubtless must act injuriously upon the lungs; seeing that the nuisance can be obviated it is an unnecessary evil, and blame rests somewhere in the fan not having been applied before to such machinery. It is now 50 years ago since it was in operation in some of the spindle and other grinding factories of Sheffield, and for 40 years it has been used to draw the disengaged dust from the preparatory machines of the cotton manufactories; but still, in whatever direction it may be applied, it is "better late than never," and this firm deserves thanks for adopting it and setting a good example, which will no doubt be extensively followed by other makers in all countries, not only for this but for many other trades and purposes.

There were two other machines, the one for the joinery of stair work that was quite a gem and performed its functions in perfection, and another for mitreing picture frames, a very perfect instrument that will prove a most useful tool to the world. The saw frames of this house were well and substantially constructed, but in sawing they did not equal McDowall's sawing of 20 years ago, the saws seemed merely to file the wood instead of every tooth taking a good grip for itself, the face of the saws appeared to be too perpendicular to the log, that is to say, too near the line of motion, thus giving most of the duty to the unfortunate teeth that had to take the lead, but be that as it may, the sawing was feeble. This shortcoming does not apply to this firm alone, for scarcely any of our saws did more than one quarter of an inch per cut, and some foreign saws were not cutting more than one eighth of an inch; this may seem a mere trifle to notice, but it was observed and remarked upon, and such need not have been the case, because there is expeditious sawing performed in England

that would satisfy the most fastidious, and most probably (so far as England was concerned) it was due in this instance to the circumstance of the attendants being all of the engineer class, a good top sawyer upon the ground would have remedied the shortcoming, because, so far as the sawing machines were concerned, they were, in most respects, all that could be desired. It was very gratifying to observe the earnestness of purpose of the house of Ransome & Co., the evident desire to court examination of their details, which gave their whole exhibit a degree of freshness, in like manner to that of the French house of Schneider & Co., which stood opposite, producing a sort of feeling which cannot be described.

James Western Powis & Co. of London had likewise a large assortment of wood machinery all of sterling quality and fully maintaining the reputation of the firm; the list embraced machines for planing, moulding, tongueing, tenoning, mortising, boring, and sawing, including band saw for cutting iron, and machines for planing and moulding stones. One of the most interesting machines of the collection was a band saw constructed upon an entirely new arrangement. In order to adapt such machines for sawing at an angle it has hitherto been the custom to move or tilt the table to an angle to suit the required form or direction of line; this is frequently found to be very inconvenient, more especially where the mass of timber is heavy and unmanageable, because it is apt to overpower the workman, slip off the table, and probably break the saw. The machine of this firm likewise has been made with the saw table adjustable to various angles, but with an important addition which obviates the difficulty referred to; they have so made the mechanism that the saw itself can be set to incline backwards or at any angle within certain limits when such may be necessary or convenient, thus enabling the wood to be sawn at any angle although resting upon a level table; this improvement has been carried out in a most admirable and simple manner, with the upper pulley mechanism movable in an arc, and having the lower pulley the centre of motion. In the machine exhibited at Vienna there was no provision made for changing the position of the saw by the machine, nor yet for tracing from a copy the form which is required to be cut out, pack-saddles for example, but both ideas are wrapped up very conveniently in this arrangement of the band saw, and when this modification is carried out the machine will be nearly perfect. They likewise exhibited a very creditable band sawing

machine of small dimensions, intended to be worked by hand, three pulleys were employed for the saws to travel upon, the third being placed at the rear and acting as a fly wheel, and fixed at the usual 34 inches from the floor to suit the average height of men. This firm likewise displayed a new construction of a moulding and planing machine, particularly well arranged, with the driving gear placed at the rear of the machine and the point for action right in front of the attendant, some specimens of the production of this machine were shown, they were all of the first class, and the collection as a whole gave a good impression.

Samuel Worssam & Co. of London put in a good appearance with a variety of wood working machines for sawing, planing, moulding, mitreing, and saw sharpening, all were of high class, and some of the shavings which were taken off were not exceeded by any in the building. This is evidently a house that is silently working its way to the front, and it was a pleasure to many to observe the evidence of painstaking which they must bestow upon each article, not only a mere spurt for the national reputation as well as that of the firm, but it shows that it must be due to their established system of working ; defects in this group were difficult to find so far as they depended upon the drawing office or the workshop, any faults that did exist were of the kind which had better be referred to in a general way, as they apply to almost every house in this and other countries, and all spring from the same source, namely, a want of real practical experience in designing the mechanism for fixing the cutters and other instruments ; this is a desideratum much easier to feel and point out than to remedy, and in any case this firm fully sustained England's reputation in the great show at Vienna.

T. Robinson & Son of Rochdale had likewise a fine display of wood machinery for sawing, planing, moulding, boring, mortising, dovetailing, and a tool sharpener, the entire collection being characterized with the well known solidity of construction for which they are so justly celebrated ; still, they did not come up to the same place in general opinion as they held in Paris ; a certain slovenliness pervaded the group, showing that sufficient care has not been bestowed upon the practical detail construction of several of the working parts, and proving that they had not been subjected to the same severe and rigid examination before leaving the hands of the workmen as had been bestowed by some of the other exhibiting firms ; with this exception, however, their whole display had real merit,

and for ordinary hard working such machines will probably fulfil their functions and give as good satisfaction as any of the same class of machines made by the other firms, for in regard to soundness of the general construction they were not surpassed by any wood working machinery shown at Vienna. Their dovetailing machine was exceptionally beautiful, it had the spirit and refinement of the original pervading every detail, and its working was exquisite, and had every other machine been equal to the "Armstrong," their display would have been super-elevated unquestionably.

C. Powis & Co. of Millwall, London, made a very fair display upon a limited scale. It contained some very interesting machines; their Blanchard lathe was the object of considerable attention, and likewise their machine for finishing the ends of the spokes of carriage wheels; but from some cause there was a slight want of character pervading their several articles. It is difficult to understand why this firm should persist in perpetuating arrangements that are now considered to be not the best for such purposes, the two machines referred to, as examples, and more particularly the Blanchard lathe, which is a tool that has been developed in so many different ways by the most skilful, by Ames especially, and by several other men both in England and elsewhere, who have introduced arrangements that not only reduce the cost of construction, but likewise involve considerably less friction in the actual working; still, after all, they were passably good machines and could not have been spared from the English collection at Vienna, because the exhibition of this class of special machines served to give a breadth to the English display which was all the more necessary from the circumstance that most of the other firms adhered to the ordinary kinds of wood-working machinery; hence the admiration that was bestowed upon them. There is something more in this than would appear at first sight; what was the attraction that drew such special attention upon these articles, as well as upon the American novelties, and the new features in the French department? the reason is not far to seek, they are not so common as other things and therefore excite greater interest, and it would be precisely the same even if they were not so good; there is a philosophy underlying every phenomenon that occurs, in regard to such causes acting on the minds of numbers of men, if it can only be correctly understood.

A machine for rending laths from a circular block of wood, designed by Colonel Gordon, R.E., was well con-

structed and performed its work admirably. It is a sort of lathe with a knife or cutting instrument the entire length of the block, the slide rest having a transverse motion equal to the required thickness of the endless shaving; instead, however, of the lath coming off the reel as a mere shaving there is in addition and parallel with it a roller filled with thin sharp knives which press upon the upper surface of the block as it revolves and with a force sufficient to indent the knives to a depth equal to the required thickness of the lath, thus the shaving, instead of being entire, is split into narrow pieces equal to the pitch of the knives upon the roller. Objections were raised by German engineers in regard to the advantage of having such a machine at all, on account of cutting up wood for such a purpose, but be that as it may, it answers the purpose very well. The same kind of machine, on a small scale, has been used in the north of Germany for making matches, for which work it must be equally well fitted, and the principle is applicable to many other purposes and should not be lost sight of. The lath machine is well designed, and reflects credit on the maker, but it would be greatly improved if the speed at which it is driven were to vary inversely as the diameter of the wooden block under operation.

Before leaving the wood machinery a few words may be said in regard to the angle at which we set our planing instruments, our cutting tools were fixed at different angles for the same class of work, not only by different firms, but even some firms had different angles in their several machines, evidently showing that there is a lack of knowledge of the elementary principle involved; this is a matter which concerns the most vital part of wood working and should be thoroughly thought out now and settled for good. Likewise in regard to our mode of fixing the instruments, they were not in every case as they should have been, this also requires reducing to a principle in order to insure precision and readiness of fixing, and above all, safety when fixed.

Reference has already been made to the action of our frame saws, but there is yet a more serious matter, namely, in regard to the *quality* of our band saws, which concerns not only the firms that make the actual ribbons in the first place, but in the second place likewise it affects the makers of band saw machinery, for although the machine is now almost as well made as it can be, still the saws are inferior to the machines; and thirdly, it concerns the users of such

ribbon saws more especially, because they are the real sufferers from the inferiority. What is the use of a perfect band sawing machine unless the saws are equal to it. The truth must be told, that at the present time our saws are not equal to our machines, nor are they so good as those made in France from Sheffield steel; we can make as good saws as can be desired, but how comes it that the said Anglo-French saws stand to their work better than the English saws, and what is more, command a better price in London? Is not this subject worth investigation by our nation? Do we prefer selling a large quantity at a low price rather than a good quality at a higher price? To give this article the proper temper, toughness, and tenacity, requires something more than the mere performance of the "mechanical saw" process, there is something in addition wanted, and this desideratum requires thinking. The circumstance of intellect underlying the mechanical production of these ribbon saws is not singular, but we are busy, and saws are light, and left to be worked by wrong hands, hence superficial workmanship in band saws is not only damaging to our country both in name and in pocket, but is just as bad as the adulteration of food, and should be treated in the same manner. It will now be difficult to remedy this matter unless the machine makers and saw users act in concert, and induce some good firms to take up their manufacture, who would strive after the highest quality; were they to do so, they would in a few years obtain the highest price, for a saw that will perform twice the duty is really worth more than twice the value. It is a reproach to us that the French saw-maker sends to England for the steel, which bears the carriage from Sheffield to Valentigney, Doubs, and returns to us the ribbon saws (ready for our machines) which we prefer to our own.

As already stated the firm of Sharp, Stewart, & Co. exhibited a few specimens of their machine tools for screwing, planing, slotting, slot-drilling, lathe for boring tyres, and a drilling machine for the inside of railway wheels, each tool having an article in its grasp to show the quality of its own execution, and without being touched either by file or polish. In their slot-drilling machines the headstocks have intermittent self-acting feed motions whereby the drills are made to descend simultaneously with the reversing of the traverse motions, and to revolve at speeds depending upon the diameter of the drills; the reciprocating motions are graduated in such a manner as to define the length of the grooves without any setting out by a

skilful hand, and the combined result is, that the channel is left perfect for the reception of the key without any resort to files being necessary. The variety of purposes to which this class of machine is now applied is increasing from day to day, and the quality of the results as well as the economy of the process, compares most favourably with the old system. They likewise exhibited one of Sellers' patent screwing machines made by themselves; the great feature of this tool is, that the thread is really cut out, that no setting up is necessary, the effect resembling that of a screw-cutting lathe, one pass through is sufficient, when the dies release systematically and the bolt is drawn out complete without stopping the machine or having to reverse. Every one of their machines was as perfect as it could be made at the present time, it is therefore useless to say anything more in their favour, except to again recommend their tools as a study for our young tool-makers.

De Bergue & Co., of Manchester, made a very good display of their well known machines for boiler and girder rivetting, rivet making, punching, and shearing, all first class tools and with a very distinctive and highly commendable character of their own. Their machines were shown in action, lead being employed where heat was required for iron; the compensation arrangement of the rivet maker, for affording temporary relief during an emergency is well carried out, and is so contrived that no ultimate loss in the complete formation of the head is incurred. Their angle cutting is beautifully sharp and on the square, and the tool for removing the selvage from the heads of rivets answers the purpose most satisfactorily. For some reason, however, the effect produced by the action of these tools was scarcely equal to that made by them in Paris, the resilience was excessive, and although such was not really the case yet the idea was conveyed of their unfitness for those dimensions of iron that were cut through. The punching was not first class, the back of the hole was broken and ragged, a condition that was not owing to any fault of the machine proper, but was due to the want of foresight on the part of those who worked the machines; this was throwing away a good chance, and Manchester could not afford to do so at Vienna, when machines are worked the effect should be perfection, otherwise it is better to let them stand still.

Nottingham sent two collections of tools; that of Messrs. New & Co., was very large, the other, of Messrs. Hind and Son, was less extensive. These machines were not to be

compared with many foreign tools shown at Vienna, and Nottingham was presumptuous to send such a large number where the most experienced scarcely dared to venture, except with trepidation. These machines were characterized by no special features that require reference; much regret was frequently expressed that Nottingham had not furnished more of the specialities for which it is so justly celebrated, even a complete set of her best washing machinery would have been most acceptable, because they were required by England for strategic purposes, on that occasion.

A few other small machine tools for metal were exhibited amongst other descriptions of miscellaneous articles, but they produced no impression. It will thus be seen how sparse we were in this branch, and it is to be hoped that at the next International Exhibition we shall put in a better appearance, if only in justice to ourselves, and commensurate with the position that we occupy before the world.

In Nasmyth hammers we made a fair display although not equal to what we might have done had our strength been put out in full force; at the same time some of our best houses were upon the ground, and every article was very good and not easy to be surpassed. The most remarkable features were the almost entire abandonment of the old self-acting motion of the early hammers, and the substitution of new devices, and in the use of hand gear only in all attempts to show off the working. There is no real saving, as a general rule, by the self-acting arrangement, because one attendant is required in either case, and on the other hand there is frequently a positive loss in the effect of the blow. By hand working, with steam on top of piston, the full force can be more readily maintained until the blow is fully delivered, it is thus more of a "dead blow" than was formerly the case with the other system.

The fact of Thwaites and Carbutt of Bradford, Yorkshire, being at Vienna is enough to show that we had something worthy of England, yet disappointment was expressed that they had not sent one of their larger sized hammers. All who were at Paris in 1867 must remember the superb hammer there shown by this firm, with wrought-iron framing in all its inherent harmony of outline. On this occasion the hammer sent was a small 7 cwt. fitted with hollow cast iron standards, but notwithstanding this it was the most winning hammer in the whole exhibition, and excited general admiration, not only in regard to its effec-

tive proportions but also in the rapidity with which it delivered "dead blows" one after another, either self-acting or by hand. The latter recommendation of course depended greatly upon the representative of the firm who manipulated the hammer, still it was a marvel of perfection in almost every one of its details, and fully sustained our character. This firm likewise exhibited one of Root's blowers, of large dimensions and of sound construction; this machine in its action resembles the blowing cylinder rather than the fan, the latter merely gives centrifugal force to the air, and the effect depends upon the area of outlet until the united area of outlet equals the intake, the power required being in due proportion to the outlets. In this blower the whole of the air admitted has to be forced out (as in a pair of bellows, however small the aperture may be), hence its action is very decided, and it is superseding the fan for many purposes, especially in melting iron in cupolas. At Vienna, this blower was put to a severe ordeal by having the outlet almost closed, the force of the blast was tremendous, and was limited only by an insufficiency of power in the motor, (an engine of 15 horse-power, which was combined with and formed part of the apparatus) to overcome the resistance. These two articles, both so excellent, seen by several millions of visitors, must add greatly to the reputation of this firm, and repay them for the outlay of exhibiting, but it would have been different had they not worked the machines at their utmost, which is a secret worth knowing.

The Kirkstall Forge Company had several hammers, all of good, solid construction, chiefly such as they make in ordinary manufacture for commerce, and without much attempt being made to produce a sensation. The hammers made by this old established house fully maintain its past reputation; they exhibited the largest hammer from England (a 50 cwt.), but no attempt was made to work it, chiefly on account of the surroundings. A three cwt. hammer was the only one shown in action by them.

This firm is remarkable for the hearty support which they gave to the introduction of the system of admitting steam above the piston as an auxiliary to gravitation, thus augmenting the velocity and thereby increasing the effect and rapidity of action. Their hammers are all on the "Naylor system," which has greatly commended itself all over the continent as well as in England.

B. and S. Massey of Manchester had a very good display of small hammers most carefully got up, and showing the determination of this firm to get to the front. Their

hammers have all the recent improvements and they are following in Mr. Nasmyth's steps with steam stamps, a most useful tool for all kinds of smithing articles that have to be repeated. A number of them which were made at Patricroft some 20 years ago have been at work ever since and have given great satisfaction. It is encouraging to find this new firm with steam stamps on fresh designs of their own, beautifully constructed and well fitted for their work; some of the details gave evidence of their having been hastily put together, but such faults were more accidental than inherent, and certainly the manner in which the steam stamp did its work was most decided, no mistake with regard to a "dead blow" being given by this apparatus, for there the hammer remains upon the die in which the forging is contained, the article is blocked out of a viscous mass into some intricate form, it may be the trunnion piece of small guns, or parts of small-arms, or anything difficult to forge in the ordinary manner, and the great advantage is, that the soft iron being in a die is compressed and rendered very sound.

Davis and Primrose of Leith had a small hammer very neatly constructed and possibly in as few parts as have yet been combined by any maker; three parts, standard, cylinder, and piston (which also is the hammer), with a handle to work the slide valve, are all that could be seen, although adapted with an arrangement for gravity only, or for action with steam on piston as required. In their hammer there is no self-acting motion, and the simplicity and cost of manufacture is thereby reduced to minimum. There is a wide field for such hammers in smithies where the ordinary hammers have not yet penetrated on account of the expense, and this firm deserves credit for their appearance at Vienna.

Mr. Davies of Crumlin, Monmouthshire, exhibited several of his well known steam strikers, which resemble the ordinary sledge or fore hammer of the smith, but here worked by steam, air, or water power, the action is marvellous when in good hands, the hammer descends at will in any direction or with any force of blow within limits, and it is a most handy tool. Unfortunately those at Vienna were not properly worked, the attendant was an entire stranger to the machine and stood in absolute terror of his own blows. It is a great mistake to go to an exhibition with a machine of this kind without sending a man who can play with it, and show its value; still enough was seen to convey its great merit to those who could appreciate its worth.

A machine for moulding spur or bevel wheels was exhibited by Mr. George Scott, of Manchester. It is not often that the machinist ventures into the foundry, sand is not a congenial material for an intricate machine as nice in its adjustments as a lathe, and intended for divisions involving the exact pitch of wheels to the hundredth part of an inch; Mr. Scott has however ventured and succeeded most admirably, and his invention has been already copied by some of our competitors. The machine in some respects resembles a radial drilling machine consisting of a vertical spindle in a corresponding socket sunk in the floor, the spindle carries a radial slide-rest arm, adjustable for the diameter and fitted with vertical slide for the depth, the division of the circle being obtained from the intermediate mechanism between the respective parts, consisting of change-wheels that are capable of dividing the circle indefinitely and with the utmost precision, because if such a machine is not absolutely true it is useless. Machines of this class are invaluable and tend to reduce the cost of engineering plant, inasmuch as it is only necessary to make a few teeth, which the machine introduces seriatum until the entire number are moulded. Surprise was expressed that Mr. Scott employed cast wheels for his divisors, they were certainly beautiful castings, but it is surely worth while to have them cut from blanks seeing that the object in view is truth, and that their whole province is solely to transmit their character of truth to the teeth of wheels *ad infinitum*.

In the whole Exhibition perhaps there was not a more interesting tool than the double bar pentagraph machine for engraving brass cylinders for calico printing machinery, which was shown by the firm of Lockett, Leake, and Company, of Manchester; it was a real triumph of art, and the perfection of its execution was a treat to behold, the accuracy whereby form or outline could be transferred from one surface to another was exquisite, and indicated the direction we have to go as a race, in order to bring the beautiful within the reach of those who cannot afford the most expensive products of the artist who works by his own immediate skill. Manchester like Birmingham is a mine of wealth in all kinds of mechanism if it would only show it.

The display of textile machinery, considered relatively, was not generally so conspicuous at Vienna as was the case at former Exhibitions. On the present occasion we certainly contributed our fair and proportionate share, and came out of the competition with a corresponding share of

honour. The firm which stands pre-eminent above all compeers in this branch is that of Platt Brothers & Co., of Oldham, their entire display was simply magnificent, and taken altogether was our best in the machinery group, and the nation may rest assured that the credit of England was fully maintained in this collection. To do justice to the various machines shown by Platt Brothers & Co., would need the whole space occupied by this report. With the exception of a machine for ginning cotton, they confined their exhibit to the woollen manufacture, which was carried out consecutively from almost the commencement to the final yarn woven into cloth, the preparatory machines consisting of a succession of carding engines for scribbling, for the intermediate stage, and lastly for carding with the condenser on Martin's principle. The one machine of the whole exhibit that excited unbounded admiration was a new description of self-acting mule for spinning short wool, it was full of ingenious devices for dealing gently with the yarn in all its stages, from the time it enters the mule until finally wound up as a cop upon the spindles.

The wool having first been carded and passed through a condenser is wound on bobbins in the form of round untwisted "slivers," in this form the wool was taken to the mule to be spun into yarn; the bobbins were placed on surface-drums, which gave an uniform surface speed to the bobbins whatever their diameter, and so delivered the sliver at an uniform rate. The surface speeds of the bottom roller and the surface drum were so adjusted that there was no draft between them. The weight of the top rollers was sufficient to prevent the sliver being pulled through when the bottom rollers were stopped. The method of spinning approaches more nearly to the old "distaff principle" than any other now practised, the drawing and twisting going on at the same time and operating upon the same fibres; this is the reverse of the principle adopted in cotton spinning in which the draft is obtained by rollers. The process of attenuation being distinct in the latter case from the process of putting in the twist, although both may be going on at the same time; thus the rollers deliver about 30 to 40 inches of the sliver before they are stopped, the carriage and spindles continuing in motion until the end of the stretch of 72 to 76 inches, during which time the spindles are putting twist in the attenuated sliver.

The object to be attained is the reduction of the sliver and the conversion of it into a perfectly level and twisted

yarn; to accomplish this it is necessary that the rate of speed between the drawing and twisting shaft constantly change as the carriage comes out. To do this the carriage is drawn out by means of a band which is wound on a scroll, a kind of fusee, the band being wound upon the largest diameter, whilst the rollers are delivering the sliver and giving but little draft between the spindles and the rollers, no more twist is put into the sliver whilst the rollers are delivering than will just suffice to keep it from breaking by its own weight, as soon as the rollers are stopped the principal draft commences, and the sliver is quickly reduced in thickness, but as the sliver becomes finer it requires more twist to keep it together, the object being to regulate the speed of carriage so that only sufficient twist is put into the sliver to keep it from breaking. If too much twist is put into the sliver at any part during the coming out of the carriage the thread cannot be drawn, but breaks down, it will thus be seen how necessary it is to have a machine in which this can be regulated at pleasure, the eye and touch being the only guide by which it can be determined. As yarn tends to shorten by being twisted, the carriage is caused by the mechanism to move back towards the rollers to allow the shortening to take place, otherwise the ends would be twisted down or broken. The amount of movement required is governed by the quantity of twist put in; the rate or velocity is governed by the thickness of the yarn, it is obvious that this motion should be adjustable so as to comply with the necessary conditions. As soon as the yarn has received the amount of twist required, the spindles are stopped by the twist motion, and the mule having backed off the yarn from the spindles the carriage goes in, the yarn at the same time being wound upon the spindles.

This mule is so contrived that when very fine wool is spun it will put little twist into the sliver whilst the rollers are delivering so as to keep it soft and tender, to do this a stutiing motion is employed, by means of which the spindles are kept almost stationary during the first 15 inches of the outward run of the carriage, this can be put on a little earlier or later, and taken off again sooner or later, it is adjustable at pleasure, and may be used or not as required. The mule as worked in Vienna used this motion.

One of the most recondite pieces of mechanism in this mule is the nut arrangement on the quadrant-screw to which the winding-on chain is attached; this nut must

be moved farther from the centre as the cop increases in diameter, and at a rate corresponding with that at which the cop increases, and to effect this differential rate more perfectly the quadrant-screw is of a very coarse pitch at its lower end, but gradually becomes finer towards the top, the bottom end being four times the pitch of the top. This enables the governing apparatus proper to regulate the position of the nut to greater nicety; of course the nut of the quadrant is adapted to work in the variable screw.

In this apparatus the drum from which the winding chain is uncoiled, instead of being, as is usual, a parallel drum, is constructed with one end in the form of a scroll, and it is to this end that the chain is attached. As the cop is built up, the spindles at its point finish on a smaller diameter of spindle, and if the yarn is wound equally tight at every portion of its length, it follows that the spindle must have a greater velocity at the termination of the stretch, on account of the tapering of the spindle, the nearer the cop approaches completion. To accomplish this the chain is caused to unwind from the scroll part of the drum, and the smaller the cop, the further down the scroll is the chain unwound. The quadrant end of the chain, instead of being fastened to the quadrant nut in the ordinary manner, is attached to a ratchet mounted upon the quadrant-nut. This ratchet when turned round, winds the chain upon its axis, consequently as the chain is wound on the ratchet the corresponding quantity is caused to unwind from off the winding-on drum. From this it will be seen that the winding can be regulated as required to suit the taper of the spindle.

From the foregoing very imperfect description may be approximately inferred the amount of hard thinking which has been bestowed upon this one machine; but besides this, there was also shown an equally ingenious machine for worsted manufacture; it was for combing wool, in which the wool is fed into a circular comb (by nipping cylinders) in detached tufts, the fibres being cleaned by being drawn through the needles by means of rollers, leaving the residue at the back of the comb. This is a beautiful machine, both in the simplicity of its action and the perfection of its produce. Another important machine was a power loom for weaving fancy woollen cloths; it combined within itself an epitome of the geometry of motion, fitted with mechanism for ungearing and reversing motions, for turning back the loom to the broken weft without moving the shuttles,

besides letting-off motions, balance taking-up motions, and a variety of other contrivances. Altogether this was a noble display, and reflected the utmost credit upon the firm of Platt Brothers & Co.

A good show of textile machinery for jute and hemp manufacture was made by Lawson and Sons of Leeds. This collection contained some points of great importance, the result of original thinking on the part of some one. Perhaps the most conspicuous machine was that intended for softening jute, hemp, and other fibre, which was accomplished by working the fibre backwards and forwards alternately between a series of fluted rollers, with the backward movement a little less than the forward, in order that the fibre might ultimately reach the other end of the machine; the softening process was very efficiently performed. There was a good deal of noise when the machine was empty; this noise might surely be softened. It did, however, almost cease when the interior of the working space was full of material, the clash of the metal flutes being prevented by the intervention of the fibre. Their jute breaker card was well constructed in regard to solidity, and in the means for obtaining truth in the setting of the rollers in relation to the other mechanism. Some ingenuity had also been exercised in arranging the bearings for the rollers in order to have them near to their work, and likewise in the means for covering over the more dangerous parts of the mechanism, so contrived that instant admission was afforded to the attendant when necessary. A study of the less important devices introduced by this firm into their structures would well repay the student; for example, the framework at each end of the machine, in addition to performing their proper function, are made to serve as wheel guards, thus forming both a support and a protection to the gearing. Another feature observable, and one that shows the progress in construction which is going on amongst us, was the absence of fixings. In the older types of machinery a bracket was fixed here, and a stud there as circumstances required, but the growth of the reign of law in the drawing-office is gradually eliminating such parts by having these and other appendages made an integral part of the framing.

The most ingenious machine belonging to this firm was that for preparing hemp for the spinning machine; the object was to lay the hemp fibre side by side in order to get rid of the entanglement to which it had been subjected from the time of harvest until the final handling when

being put into the machine. The principle of the mechanism resembles the action of two combs (here termed "hackles"). One comb, by moving rather faster than the other comb, gently pulls the fibre away from the slow moving comb, and at length delivers the combed fibre to a pair of rollers. To understand the action it has to be explained that these hackle combs are mounted on endless bands, which although in company, keep up an incessant strife over the hemp, the slower comb holding on, and the other with more vigour (due to its greater speed) is gradually tearing away, but the ultimate result is a beautiful filament, misnamed a "sliver," which by another piece of mechanism is twisted into spun yarn. A notable point in these spinning machines was the mode of driving the spindles by belts instead of by gearing, which enabled a higher speed to be attained. Altogether this was a good display, the only defect observable being a want of consistency in the harmony pervading the entire collection, and the noise made by some parts of the mechanism when empty.

Combe and Barbour, of Belfast, made a great effort with flax and other machinery, and their exhibit was much admired, perhaps all the more due to the fact that it was from Ireland, from which country there were but few other things of the machine class. The textile machinery of this firm, although intended for the same purpose as that of the house previously mentioned, was yet quite distinct, and the essential points of the mechanism had comparatively little similarity; the distinguishing feature was gentleness of action by the respective hackles, the substitution of gravity for purposes where the more determined action of the machine might cause fracture, and the introduction of self-acting movements to operations which, until recently, had been performed by boys. Much forethought had been exercised in the contriving of some of the arrangements in order to preserve the more delicate parts of the machine from injury, the wooden rollers for instance; in most cases the pressure weight is allowed to remain upon them at all times, hence, after standing still over Sunday, or during the night, an indentation is made, which hastens the time for their becoming unserviceable; but this firm, by very simple mechanism of compound leverage, relieves the pressure entirely when the machine ceases work. One of their machines, termed a "roving frame," has some most ingenious points introduced into it in order to attain the recondite movements that are necessary in that machine. The object is to have a varying rate of motion depending upon

the conditions of the bobbin in winding the rove; this varying rate of motion to come direct from a shaft that always moves at the same velocity, presents conditions which at first are apparently impossible, is here carried out in a most admirable and simple manner. A shaft that revolves at a definite speed carries two cones, with the small ends toward each other, consequently there is a valley between them for the reception of a driving band which conveys the motion elsewhere; these cones are not entire in their surfaces, but are prongs, whereby one cone may slip in between the prongs of the other cone and thereby make a pulley of any required diameter to suit the immediate requirements of the rove winding, the various movements being determined by the mechanism without consulting the attendants either for advice or assistance. This firm had likewise performed a generous deed which but few have copied. Machine tool making firms had sent machines because they intend to sell them; an American house sent screw-making machines with the same object; but Messrs. Combe & Co. are in the position of a screw-making firm which sent the machine which earned their living; this firm sent the actual machine by which they flute the rollers required in their business as textile machine makers, thus throwing it open to the whole world.

Altogether, our three textile machinery exhibiting firms did their duty nobly, and like the greater number of the other textile houses they did not give away working drawings, nor circulate descriptions too freely, but merely afforded sufficient information to make people acquainted with the main points, such descriptions as were given, however, were ample, although they did not impart that knowledge which would enable rivals to copy without sanction.

It might be supposed, from what we have seen at former exhibitions, that there was little room for improvement in power looms, but this is not the case. A most important display of these articles for weaving various classes of goods were shown by Mr. George Hodgson of Bradford, Yorkshire; none of them were of the common sort for calico, but were all for fabrics, which involved frequent changes of the shuttle in order to bring out the tartan patterns or other fancy fabrics, twills, cobourgs, or other sorts; besides, there were looms for high speed, as used for alpaca, mohair, silk, and worsted, looms with six shuttles and with the Jacquard mechanism; but what is more to the purpose, and half the battle, the machines were admirably worked, with the hearty good will of the attendants,

thereby making a good impression on the public mind; and every credit is due to Mr. Hodgson and his workpeople.

A self-acting spooling machine, the invention of Weild, was shown by two houses. This machine contains a wonderful combination of ingenuity; it supplies itself with the empty series of bobbins, fills them with 100 yards of thread, inserts the thread, polishes the surfaces, delivers it complete, and then passes on to the next series of empty bobbins continuously. That a piece of machinery should perform all these actions by automatic arrangement is a marvel, and great interest was evinced in its performance. The firm of Kerr, Price & Co., of Paisley, was one of the exhibitors of Weild's machine, as well as of another smaller machine for the same purpose, but worked more by hand dexterity, and at which they were very fortunate in having an expert who showed it off to great advantage, making it a centre of attraction in the English department. Weild's spooling machine was likewise exhibited by Clark and Company of Paisley; both machines were so well made, and so perfect in their action, that it was difficult to say which was the better, nor was there anything in the whole exhibition to equal either machine for the special purpose, and the assiduity of both firms was a credit to their country.

One of the most magnificent machines in the British collection was exhibited by Mather and Platt of Manchester. The object of the apparatus was to print calico, it was fitted with the requisite mechanism to print with twelve different colours at one operation; the machine was provided with a self-contained double cylinder steam engine arranged in the most consistent manner throughout, and provided with every facility for setting to work gently and stopping instantly; the machine was shown in action, but not with all its colours, on account of the waste which such a course would have involved, still sufficient was shown to enable the mechanism to be understood, as well as to delight its numerous admirers. The mechanism, when taken in detail, is simple enough, but taken as a whole it seemed formidable; each colour has a separate printing roller with a duct of the required liquid, and each roller contains the pattern of the part which it has to print; these separate printers are arranged around a large cylinder and between them passes the calico, rushing in white as snow, and coming out at the end marked with a beautiful pattern. The machine necessarily contains a series of steam rollers for drying the colour as the calico

flies along, in order to prevent smearing. This machine made a decided impression in our favour, and it well deserved the medal for progress which was awarded to the firm.

In the display of sewing machines as a whole we have great reason to be well satisfied, more especially with that of Bradbury & Co., of Oldham, which was indeed superb, alike in regard to real goodness, novelty, and variety, both for domestic and manufacturing purposes, and probably there were none better in the whole Exhibition; this is saying a great deal when it is considered that the display from most countries was characterized by a very high standard of excellence. The amount of ingenuity which has been brought to bear upon the sewing machine in order to simplify the details, to render it more convenient, to reduce the friction, the noise, and the cost, yet without losing the essential conditions, is indeed marvellous, and can only be appreciated by those who have had to examine them by the hundred. At Vienna, some of the exhibitors expressed dissatisfaction at the short space of time that was given by the jurors to the examination of the different articles, forgetting that probably hundreds had been examined previously, and that the minds of the jurors were so saturated with the mechanism as to be rendered capable of seeing the merits or defects at a glance, and able to discuss every detail at the following meeting. Want of space precludes any attempt at technical description, and it is unnecessary, because all the makers distributed their books so freely. Messrs. Bradbury's machines were made in different ways, some on the well known Howe system combined with certain modifications; they had some machines with a more elastic construction of mechanism that seemed to make beautiful stitching, and the greater number of the machines were furnished with all the little appliances for hemming, braiding, and other such like purposes.

The firm of S. M. Wanzer & Co., of London, had likewise a display of some admirable machines very neatly and skilfully constructed, and capable of working with a small expenditure of effort on the part of the operator, and apparently they performed good sound work in stitching and sewing. The same may be said of another exhibit by the Canadian firm of R. M. Wanzer & Co., both were good, and both had awarded to them the medal for merit.

The firm of Nussey and Pilling, of Leeds, exhibited a number of very good sewing machines; this is evidently

a house that is determined to do well, and although at the present time they may not be quite up to some of the other houses, still, from the clear and interesting manner in which they have opened up the subject, they show that any shortcoming is not for want of understanding what the sewing machine ought to be. No machines worked with less noise, none seemed better prepared for the regulation and tension of the thread, and the shuttle arrangement was most perfect and efficient; still there was a slight want of natural character, and fault had taken the place of true principle in some of the details, but nevertheless their machines seemed to perform their work in a very satisfactory manner, and it is difficult to say which did the best when all were so very good.

The firm of G. W. Bacon & Co., of London, made a fair exhibition of extremely small sewing machines of very simple construction, and perhaps their most distinguishing feature was the price at which they can be sold, which made it a puzzle to many to find out how they could be produced so cheaply. Of course such light machines are not intended to compete with the larger machines which are sold at double the price, still there is a great amount of fine sewing to be done in the world for which these machines may be quite sufficient; but in any case, this firm is deserving of credit for the attempt to put a cheap and good sewing machine into the hands of those who are not able to purchase a more expensive one.

The automaton sewing machine was shewn by the firm of J. and W. Moore, of Salisbury, which possibly may be the precursor of a new type, there being room for improvement in existing machines; still, the avenues in this direction are closing up, and it will take some ingenuity to push the old types into the back ground. Taken as a whole, the British collection of sewing machines was a credit to all concerned in their production.

Great Britain did not come out strong in the boot and shoe-making department. Mr. Henry Salter of London had a sewing machine for welting and soling boots and shoes, which performed its work very well, but whether sewing is better than the system of using screwed brass wire introduced by some of the boot and shoe-making firms in Leicester and elsewhere it is difficult to say. The latter mode of screwing the sole to the "upper" without the previous use of an awl makes a strong and satisfactory shoe when properly rivetted, and it is likewise economical, one machine being capable of turning out 500 pairs daily.

For the lighter sewing of the seams of the uppers, the class of sewing machine employed by Mr. Salter is invaluable, and opens up a great question which the nation will shortly have to consider, whether boots and shoes should not now be manufactured rather than made. Taking it up as a subject for one of the annual exhibitions at South Kensington would assist in precipitating matters, and doubtless would lead to improvement for the good both of workers and wearers.

A machine for washing wool was exhibited by Messrs. McNaught of Rochdale, which performed its work most satisfactorily and economically. This machine discharges two duties; at one end it contains a vessel in which the dirty wool is immersed and soaked in a solution of caustic soda, in order to soften the dirt and prepare it for disintegration from the wool. After a certain period has elapsed (depending on the condition), the soaked wool is moved forward by means of reciprocating mechanism, it is then seized by squeezing rollers and tumbled into another part of the machine, where it comes in contact immediately with mechanical rakes, or rather forks, the prongs of which reach nearly to the bottom of the second vessel, which contains an alkali; a succession of these forks are kept moving by a train of wheels, all adjustable as to crank radius in order to modify the extent of movement that the rakes are to impart to the wool. When the wool reaches the rake number one its troubles commence; it is carried forward, and rake after rake continues to move it about during the entire journey, until at length it reaches a haven of repose at the farther end of the machine, by which time it has become a clean wool, almost as white as snow. In a machine of this nature, perhaps, there is not much scope for the inventor, but still it may be clumsily or cleverly designed, or part of both in combination; in this case it was particularly well designed for its work, with every means provided for re-adjustment; besides, it was neatly and at the same time substantially made, and brass was employed for every part where it was requisite. This machine possessed character; from the style of construction it was probably expensive, but the quantity and quality of its produce will soon prove that the first cost is money well laid out. It is one of the results of a patent that a man feels warranted in making a machine really good, whereas if it has to be made under a hard competition the style is often found to degenerate to the cheap and worthless.

An interesting display of machinery for washing, wringing, drying, starching, mangling, and calendering the various articles of the laundry, by Thomas Bradford & Co., of Fleet Street, London, was greatly admired, not only for simplicity, but especially for the gentle manner in which the machines severally act upon the clothes or other things submitted to their treatment. The machines were of all sizes, suitable for almost every class of duty, all made in a highly creditable manner, and were exceedingly rapid in the performance of their several functions. Nothing more forcibly shows the progress the world is making in regard to common things than an exhibition of this description; all the principles for softening and rinsing the soiled fabrics, and the science brought to bear on the drying and smoothing, are the results of close study.

Two firms exhibited a similar apparatus for straining pulp for paper making; only one of them however was complete for work, and was shown in action by the firm of J. Bertram and Son, of Edinburgh. The principal part of the apparatus is a hollow vessel in the form of a square box, in which a vacuum is maintained by a pump; the four sides of the said box are composed of extremely fine grating made of brass, the grid being so fine as to allow the proper pulp to pass through, but to withhold the motes that may be mixed with the liquid. The square perforated vessel revolves in a cistern containing the pulp, which rushes through the fine opening, assisted by the pressure of the atmosphere; this part of the apparatus was well constructed, and seemed to perform its work most efficiently, but the mechanism for working the exhaust pump was not in keeping, and was evidently not designed by the same hand. Fortunately, the attendant was a good workman, and by a little transposing of the parts the machine was rendered more passable; still, blame rests somewhere, and more especially as the odium falls upon the nation, which cannot afford to bear it now that everything is becoming so perfect in every competing country. In all other respects it was a good machine, excited considerable interest, and gained the medal for progress, which it well deserved, notwithstanding the blemish. Mr. Henry Watson, of Newcastle-upon-Tyne, was the other exhibitor,* who brought forward the pulp part of the apparatus, which, like the one that was in motion, was of first class workmanship, so far as it was completed.

A machine which excited great admiration was the "Victory" printing and folding machine, exhibited by that

company. This machine was employed to print an Austrian newspaper, consequently there was ample opportunity of observing its behaviour from day to day. Nothing could have been more satisfactory, both as regards printing and folding, as well as the good design and good workmanship of the mechanism. This machine bore considerable resemblance to the "Walter" machine; it printed from the web continuously, and the newspapers were delivered (neatly folded) into a vault beneath the floor. From the circumstance that so many of its printing features were like the "Walter," it is impossible for the writer to say how much may have been copied or how much is original, but certainly it is a superb machine, and to one not an expert in printing, it seems to be all that can be desired. There was perhaps one exception, namely, the noise made by the rapidly revolving metal wheels, but surely this can be modified by some means for deadening sound being introduced, for if it could be made approximately noiseless, its value would be enhanced in general estimation.

A machine for dressing stones, the invention of Mr. Holmes, was exhibited by the Stone Dressing Company, of Westminster, which performed its work in a highly satisfactory manner, the machine being soundly constructed throughout. The acting instruments were made of chilled cast-iron, fixed on both sides of a reversible tool holder, and their action resembled that of the ordinary chisel in the hand of the stone mason, but without the disadvantage due to impact. The stone is placed on the bed of a planing machine, and moves at the rate of four feet per minute under the cutting tools, which extend the whole breadth of the stone, and the stone is acted upon in both directions, so that a few passes are sufficient to give the stone a comparatively smooth surface. The machine is chiefly intended for stones of the Portland class, including sandstone or marble, and is reported to dress such materials at the price of one penny per superficial foot, which is considerably less than the cost which would have to be incurred in performing the work by hand labour. This is a good machine, and there is abundance of useful duty before it laid up in the future.

A machine for grinding clay, ganister, chalk, and other materials was exhibited by the firm of Heslop and Wilson, of Newcastle-upon-Tyne. It had no striking feature to recommend it, but good common sense was displayed in conceiving the general idea, it being simply the usual incorporating mill with a pair of runners, and the circular pan

worked by an independent steam engine, the whole apparatus being placed on a railway truck. The ordinary custom is to take the material to the mill, but now the mill will go to materials, and thus reduce the cost due to transport. As a machine, it was soundly constructed and well fitted for the intended function, and the firm acted wisely in sending it to Vienna, as its merit received the full approbation of all who were prepared to appreciate its value practically.

The firm of T. L. Derham, of Leeds, exhibited a brick-making machine, and a model of a brick kiln on a new arrangement of construction, both of which were much admired. The rough, strong, dry clay was given to the brick-making machine, which worked and digested it in a vertical cylinder and thoroughly pulverized it, withdrew the small stones and squirted the dry clay into a continuous stream of bricks, so hard and dry that comparatively little kiln drying would be necessary to complete the process. It is a good machine, and much thought was required for its production. This seems to be the proper direction to work in, in order to combine quality with economy, and as an observer remarked, "It will be bad to beat."

The Messrs. Atkins & Co., of Fleet Street, London, exhibited some water filters which were exceedingly efficient both in their action and in their adaptation for being cleaned after continued use. Their leading feature was a solid yet porous block of animal charcoal, through which the water has to pass, the charcoal being just sufficiently porous to admit the pure water to percolate, but yet close enough to reject the impurities held in solution, which are consequently deposited upon its exterior surface, thus forming a dirty coating on the block of charcoal, to be removed by washing when deemed necessary, and which is best accomplished with warm water and a hard brush. Articles of this nature, although unpretending, are yet calculated to be of immense value to mankind, the advantage to be derived from the use of pure water for drinking or domestic purposes is undoubted, and as population concentrates, and the difficulty of obtaining wholesome water increases, such filtering arrangements as those submitted by Messrs. Atkins will be greatly appreciated in the future.

The firm of Siebe and Gorman, of London, exhibited some admirable ice-making apparatus, most scientific in principle and beautifully simple in mechanism. The agent is ether, which in the liquid state circulates through the water to be congealed without coming in actual contact,

a pump creates a partial vacuum over the ether, thus requiring heat to enable it to assume the vapour condition; but there is no heat to be found in the vessel except that which is contained in the water, consequently the vapour robs the water, and the latter becomes ice; meanwhile, the vapour having served its own purpose, spends its heat on the journey home, and has again to become a liquid, and so the machine works on *ad infinitum*.

Messrs. W. Lawrence and Company, of St. Mary Axe, London, exhibited a refrigerator constructed on really scientific principles, and intended for the cooling of milk. The cooling part of the apparatus consists of thin copper corrugated surfaces of great extent, which are kept wet, thus exposing the film of water to evaporation, which carries off the sensible heat in the condition of latent heat to maintain the vapour condition. The warm milk, or any other liquid to be cooled, passes by gravity through a winding labyrinth within the corrugated part of the structure, has to give up its heat during the journey downwards, and by simply running through, it is greatly reduced in temperature. This is likely to become a most useful article for many departments of daily life, and it deserves to meet with success, This principle is not applied here for the first time; there are steam engines in England wherein condensation is effected by having a series of thin copper pipes kept wet on the outside by a downward trickle of water, the steam passes into the interior and is there robbed of its heat by the exterior evaporation, and the condensed steam runs out at the bottom in the condition of distilled water. None the less credit, however, is due to Messrs. Lawrence, who have managed to produce an article which will prove of great practical value.

Dows, Clark and Company, of London, made a great display of first class apparatus for the manufacture of soda water and other products, which deservedly commanded considerable attention. Their appliances for combining the carbonic acid gas with water, and for all the other processes, are most ingenious, and if they did not possess the silvery splendour of a similar apparatus shown by America, still, for all practical purposes, they were as good as any shown at Vienna, and this is saying a great deal, because this particular class of articles was shown in great force by many countries, the greater number being better and more direct to the immediate point than was ever exhibited before, showing the rapid rate at which the world is improving, and likewise the increase of luxuriousness.

"The British Workmen's Hotel" was an institution at Vienna. It was a complete cooking apparatus, constructed for Her Majesty's Commissioners by Mr. Richard Adams, of Westminster. The whole plant was arranged upon a carriage with wheels, and contained within itself every appliance required for baking and boiling meat, baking, boiling, and steaming vegetables, and likewise for making tea and coffee; yet the entire "hotel" was so light, that when loaded with fuel and water complete, it could be comfortably drawn by one horse. A foreign gentleman on seeing the "British Workmen's Hotel," remarked that we English are a peculiar people; it reminded him of our sending a floating factory to the Crimea, and the setting up of saw-mills on the sea shore at Balaklava; well, and so we are peculiar, and the "hotel" was only another illustration of one of the strongest points in the national character, from which a large portion of our past success has been derived; and that we may always continue in the future to maintain the character and be worthy of our forefathers is a desire in which every patriot will heartily unite.

France.

France is certainly becoming great in machinery construction, and on this occasion she put forward her best products. The fact that M. Tresca had the selection of the houses which were to exhibit, is a sufficient explanation of the result, and the example shown in this respect was a good one for other nations to follow.

Arbey, of Paris, made a magnificent display of woodworking machines; one of their novelties was a Blanchard lathe that operated upon six wheel spokes at one time, and to make sure of the correct form, two copies were employed from which to trace; this is certainly another step in the proper direction. It was this firm that introduced the system of making planing cutters out of long thin curved blades of steel; these blades are wound upon a cylinder at equal distances, and become, through the development, a cylindrical cutting surface. When requiring to be sharpened, the cylinder turns slowly round *in situ*, and an emery wheel at high velocity, passes along in a straight line, a course which is next to perfection. Their band saws were good, although perhaps not equal to those made by Perin; they make them of all sizes; and the larger sorts (with self-acting feed) are capable of rending heavy baulks of timber. The frame saws are plain serviceable tools, in which any

defect that may exist is due to slimness, and a notable feature is the use of wooden connecting rods, properly bound with iron at the ends. Altogether there was a good deal of freshness in this collection, and many of the details were worth a careful inspection.

Perin & Co., of Paris, stand A 1 in machine tools for wood, their band saw machines especially are not to be easily surpassed. Throughout the Exhibition such machines were made in many different ways in regard to the mode of maintaining the proper tension upon the saw, more particularly for taking up the slack when the saw lengthens by the increase of temperature due to friction when at work. The majority of makers employ a counterbalance, whilst others use the adjustment of a screw, and this latter is the method applied to all Perin & Co.'s machines, it being the plan which their experience showed them to be the safest. Another important point is in regard to the manner of taking the thrust that is bestowed upon the saw when at work; many devices are resorted to with this object, Perin & Co. simply use a piece of wood, which the attendant pushes forward from time to time or when necessary, and this seems to fulfil all that is required. Some of the saws of this firm were 2½ inches in breadth, and from that downwards to the narrowest ribbon. Another point observable in most of Perin's machines was that the pulley is generally the spindle; this is done in order to secure perfect balance, which is of essential importance when running at high velocities; and lastly, when any of their machines require a "tipsy saw" it is secured by a ball and socket joint, whereby it can be made to wabble to any extent by the fixing of a nut. For their planing machines they generally employ a pitch chain, that answers admirably, and when well made is found to give no trouble. It will thus be seen that this firm knows its work thoroughly, and their collection was the object of study to engineers from all countries. Perin & Co. being the inventors of band saws, the enthusiastic German students were to be seen poring over their tools, drinking instruction at the fountain head.

F. Guilliet, of Auxerre, Yonne, exhibited some original features in wood-working mechanism, one of the most remarkable being a species of lathe for turning the naves of carriage wheels. The block of wood is made to turn slowly, and alongside it there is a rapidly revolving instrument mounted with a set of cutters, the exact profile of the required nave, this part of the apparatus is gradually brought into contact with the block, and the form is thereby

communicated, the space of one half minute only being required for the operation, and where a great many naves have to be produced this will be found a very good and useful machine. The plant for turning legs of tables was also very efficient. Some tables are made with the legs partly round and partly hexagonal, each portion was successfully accomplished by this machine with suitable revolving instruments, and the rapidity of execution was a treat to observe. The fly-cutters of this house are not made in the usual manner out of mere pieces of steel, but are forged into the form of a hollow saucer, then turned to section, and afterwards cut out into the proper contour as cutters; thus the whole of the instruments are in one piece, which is slipped on the spindle and fastened with a nut and washer, all tending to show that this exhibitor is thinking and in earnest, and knows what he is about just as well as we do ourselves.

L. Deny, of Paris, made a noble display of apparatus for coining and punching in every variety, all of the highest class, and probably not equalled by any other exhibit of the same kind at Vienna. The most remarkable feature was the immense leap forward which this firm has achieved since 1867; to see the coining presses in action was a pleasure, and they are withal so simple, and so completely under the control of the workmen as to require the minimum of manual effort in their manipulation. The press proper is made in the usual horse-shoe form, but alongside are two columns, upon which runs a shaft with fast and loose pulleys, and in addition the shaft is furnished with two large discs, which are arranged to actuate a heavy fly-wheel upon the top of the main screw of the press, the two discs are so placed that they almost touch the fly-wheel, but yet are so arranged that either the one or the other may be pressed into actual contact, consequently they will give motion in the direction due to the particular disc which is in contact, by the slightest effort applied to a lever, or when placed in the centre, even with the shaft in motion, the press consequently stands still. The execution of these machines was superb, and not in the common style, but showing a degree of mechanical refinement rare to witness. The various classes of articles produced by these punching and compressing contrivances, and by means of variously devised auxiliary instruments, were perfect marvels, and the variegated patterns that were stamped out, together with the sharp defined lines at the back, indicated a condition of tools almost perfection. It is to be hoped that

our Birmingham visitors found their way to this exhibit, because it was quite possible that it might have been overlooked, inasmuch that it was not in the main building. There were not many things shown at Vienna that afforded a greater treat than those of L. Deny, of Paris.

The firm of Dandoy-Maillard Lucq & Co., made an extensive display of machine tools, chiefly of a light construction, and which were quoted at very reasonable prices. These tools were not to our taste, although possessed of much ingenuity in many of their arrangements, their faults came from the drawing office, and they must have been designed by one who had not much practical experience in the use of such tools, besides, there was too much of fancy and too little of natural principles pervading all, although for some reason they appeared to be much admired. In respect to ingenuity they were exceedingly rich, and full of novelty in their adaptations, and no doubt there is a use for them somewhere in the world. Their drilling machines for light work were so arranged upon the top of a pillar that the pillar was made to serve as a pivot for either a table or a vice to be brought under the drill, this was very good.

Lambert & Co., of Paris, made a good display of nail-making machinery, some parts of the mechanism being very ingenious, but as a whole was not so remarkable as the variety of nails and tacks that they produce. These machines draw the wire from a reel, take hold, cut, point, and head with great rapidity and very efficiently.

Bariquand and Sons, of Paris, had a magnificent exhibit of circular cutters for engineering purposes, probably the best that has ever been submitted at any exhibition, they were of all sizes and patterns, and beautifully and accurately finished, and the prices at which they were marked were considered most reasonable, for example, a cutter 6 inches in diameter passing off into an intricate form, was quoted at 55 francs. To take up these and such like articles as a speciality is the proper course for a man to pursue.

An interesting machine was shown by Mons. Vavin, of Paris, for separating iron or steel chips from those of brass or gun metal. It consisted of two cylinders mounted with rings of magnets which seize hold of the iron and steel, but allow the chips of other metals to run down by gravity, at the same time a revolving brush sweeps the iron and steel dust away from the magnets in another direction. This machine performed its office admirably.

Bastié of Paris, exhibited a model of a machine for turning

stones, or for shaping them into square, octagonal, or any other form; the products of the machine were very good, but the model was not shown in action.

Gros, of Paris, submitted a machine for folding the edges of thin plates, in which the plate to be folded was attached to a permanent folding plate provided with space for the insertion of the edge of the plate to be bent. Thus secured, the folder was actuated by hand (or steam power when necessary) and a perfect bend in a straight line was given in an instant to the thin plate under operation.

France likewise exhibited an immense assortment of all kinds of machinery for the manufacture of soap, chocolate, soda water, and a variety of other substances, but the want of space in this report prevents their being even named. As before stated, France did well at Vienna, very few bad things were put forward, and there was very much to be admired and noted by the visitors from every country, and after all said and done, the French are an ingenious people, who are rapidly becoming highly efficient in the practical construction of machinery, and who may yet prove formidable rivals in the peaceful art of machine making.

Belgium.

Belgium, considering the extent of her population, generally contributes her fair share to each recurring exhibition; at Vienna there were several of the well known firms of former exhibitions, and amongst the number the firm of Bede & Co., of Verviers, were conspicuous; still, even among their machine tools there were not many features of a striking character to call for special remark. The tool which was most admired was a horizontal drilling machine that consisted of a vertical standard with one side constructed and planed in the usual form with dovetails in order to receive a sliding saddle, and which, by the usual means, could be raised or lowered to any level for adjustment. The horizontal spindle was mounted in its sliding saddle, and received motion in any position from a vertical shaft with continuous key-way placed within the standard; the same with the self-acting feed motion, a parallel shaft was placed outside the standard, which took motion by a strap from the driving shaft; by this means, with suitable pulley arrangements, the workman could obtain any variation in rate of feed motion to suit varying circumstances.

The firm of Martin, of Verviers, came out grandly. They are great in textile machinery, their carding machines

(especially in regard to their appendages) have become quite celebrated. Their fame at Vienna however chiefly rested upon a new spinning machine, which is most ingenious and is intended to fulfil the same office as the self-acting mule, and is therefore a rival to the Avery wool spinner in the American department. The leading characteristic of all such machines is some combination of arrangements contrived to draw out the wool while in the untwisted state of rove, and to hold one end of the part thus drawn while the extremity is receiving the final twist. In the mule this is generally accomplished by rollers performing the drawing part of the duty while the twisting and winding up is accomplished by having the spindles on a movable carriage; but in Avery's machine it is done by a reciprocating action which takes the place of the human fingers supposing it to be performed by hand, and in Martin's machine it is done in another and entirely different way. The rove is first drawn by rollers, then a considerable length of this untwisted rove is passed over a folding support, which support is counterbalanced with a definite weight, while the outer end of the yarn is being twisted by a spindle. The counterbalanced support above referred to plays the most important part, its office is simply to raise up the thread or yarn out of a straight line, while it is still soft, but as it becomes stronger (through twisting) it is drawn into a straight line by overcoming the counterbalance, and on reaching that point it comes in contact with a stationary retarding frictional surface, just sufficient to hold it fast while the ultimate twist is being imparted to the thread.

It is interesting to watch the growth of new ideas in a field which has been already explored more perhaps than any other. It might be supposed that the harvest was gathered and that nothing remained but the gleanings of the past, such however does not seem to be the case, the great secret chambers of mechanism are yet apparently unexplored, and there is still plenty of inventive work remaining for the men of the future which time will gradually unveil and evolve.

SWITZERLAND.

The firm of J. J. Rieter & Co., of Winterthur, made a fair display of good serviceable machine tools that had evidently received much attention in regard to their details. This is always a good symptom, and especially when combined with good workmanship; the tools were all of

the ordinary sorts, embracing those for planing, shaping, drilling, band-sawing, and including a radial drilling machine. This latter machine was so arranged that the radial arm could be adjusted vertically a distance of at least one foot. The only other peculiarity was rather adverse, namely, that the various handles were not concentrated at the most convenient points for the workman, which was a matter of surprise when coming from Rieter.

The firm of Alder and Rivenc, of Geneva, gave evidence of ingenuity in some of their tools, and especially in small matters of convenience in connexion therewith, one especially for facilitating the shifting of heavy articles upon a table when under operation, as in drilling. It is sometimes difficult to adjust the article to the centre point of the circle for the point of the drill to enter with precision. The means employed by this firm to obviate this difficulty consisted of a great number of steel balls (about the size of billiard balls) all of equal diameter, which were prevented from running off the table, or from spreading, by a light frame with the balls projecting at top and bottom, thus their upper surface formed a plane as good and correct as the table, and was more flexible as due to the rolling balls. They likewise exhibited one of the small machines for cutting millstones with the diamond, which seemed to be well arranged, and in good hands would be a very useful instrument, but it was evident from its performance at Vienna that it requires very careful handling indeed to make it thoroughly efficient.

Schnider and Nüsperli, of Neuenstadt, Bern, made a very pretty display of neat little convenient chucks and drills of all sorts and sizes, all of fair passable workmanship, and showing clearly that they know how drills should be made.

The firm of Rudolf Jaecklin, of Basel, made an extensive exhibit of every description of small machines and tools for tin plate working, especially for making pipes of any form or dimensions, even to making them into the shape of a ram's horn, and much ingenuity was evinced in the contriving and making of some of the devices of the different machines.

Perhaps the best show made by Switzerland in this branch was that of the firm marked No. 628 in the catalogue (Maschinenwerkstätte und Eisengiesserei, St. Georgen). The exhibit contained the entire plant for working paste into macaroni, incorporating mills, horizontal rolls, hydraulic presses, forcing pump, &c. all of a style far in advance of what we usually see employed for such purposes, and the workmanship was fully equal to the designs, the whole

being characterised by thoroughness in working out every detail to ensure convenience in their manipulation.

Switzerland as a whole made a very good display, and generally, all the various things put forward were considerably above the average.

Italy.

Italy did not make a great show with machinery when compared with some of the other countries, still she put forward a number of very creditable machines. Two pieces of mechanism submitted were exceptionally clever and original. One of them was a machine for testing and ascertaining the various physical properties of different metals, such as elasticity, tenacity, compressibility, torsional resistance, resistance to indentation, hardness, and softness. For mechanical action the lever arrangement was adopted, approximately after the American system; but in this machine the compensating arrangements were immensely more advanced and refined. The chief peculiarity however was in the instruments for recording the behaviour of the specimen when under experiment, thus placing the results beyond the possibility of error, and when we consider the minutiæ of the elongations, compressions, or otherwise, and especially the limits of elasticity, it must be admitted that the inventor undertook a very difficult task, but which has been carried out most satisfactorily, and reflects immense credit upon the scientific ability of its inventor, Colonel Conti., R.E., of the Italian army.

The second machine was of a less pretentious character so far as refinement, design, or workmanship are concerned; it was apparently made by a village carpenter, and there was no name upon it by which it could be designated. It was a machine for dressing stones, the action being made to resemble that of the stone mason, and it seemed capable of fulfilling its function most successfully. The stone to be dressed was laid upon the movable table of a planing machine, the table having a self-acting feed motion. A row of broad chisels (set at the same angle as the chisel in the left hand of the mason) stretched across the stone, the chisels being arranged in relation to a transverse beam whereby they were prevented from penetrating beyond a certain depth, the chisels were struck by a row of hammers that were raised against springs by means of a cross shaft mounted with cambs, consequently as the shaft revolved the hammers kept up a succession of blows upon the chisels, and the stone was thereby brought to

an approximately flat surface. The idea contained in this machine might be developed into a powerful stone dresser, but whether the impact system is the best for the purpose is doubtful, and more especially in the working of soft stones. Recent invention both in Great Britain and America, has been in the opposite direction, the most recent being a circular revolving knife or disc employed at Aberdeen to turn granite columns by sheer pressure, with a yielding knife to move with the stone.

Sweden.

Sweden begins to give evidence of her fitness for machinery construction. The firm of W. Gibson and Son, of Jonsered, Göteborg, made a very fair show that reflected credit both upon the thinkers and the workers engaged in the production. Their planing machine for wood was well designed and well put together, in it they employed both revolving and stationary cutters, the former to take the rough pioneer portion of the duty, while the latter take the final smoothing.

There is an old proverb which says that "the workman is known by his chips;" judged by this test, the smooth planing of this machine is first class, the shavings are so large and so good that they are afterwards made into door mats, some of which were exhibited as an application of waste material. This firm likewise showed a moulding machine upon the early American type, with wooden framing; still it performed very clean work and was quoted at a low price, and it will prove a most useful tool for the outlying parts of Northern Europe. The cutting instruments, and their sharpening were both peculiar, the cutters were long pieces of steel inserted into sockets and pinched by screws in a simple manner, and were easily withdrawn when necessary. The final sharpening was by means of a hone mounted like the usual grinding stone, the edge and side of the stone both doing duty.

The firm of E. Boëthius, of Stockholm, made an interesting display of cork manufacture very creditable to Sweden, knives being used in all the processes. Of late years in the manufacture of floats of cork, where fineness is not an object, the band saw has been used and answered very well, and required less sharpening than is the case with knives; but in these Swedish machines the sharpening is one of the leading features, there being solid emery discs, at high velocity, always on the look out and keeping every blade as sharp as a razor. There were four machines engaged in completing the bottle cork; firstly, two machines to cut and trim the

rough cork into definite shape (namely rectangular strips), the instruments employed resembling circular saws, only that there were no teeth, the edges are as sharp as can be made, and the cutting was as good as could be wished. In the third machine, the long strip passes between a series of similar revolving cutters, and is delivered as corks in regard to length, but are square instead of being round. The fourth machine had to make the square corks into round ones; the squares are put into a feeding hopper, there being two spindles in line that approach and grip the corks between them, and then turn round the cork against the edge of a stationary knife whereby the cork is made complete. This was very satisfactory considered as machinery, but the key of the position is the emery wheel.

J. and C. G. Bolinder, of Stockholm, submitted an extensive plant of mechanism suitable for the manufacture of cartridges and other articles in connexion with ammunition, such as friction tubes and bullets. The machinery for these articles has had so much attention already, both in Europe and America, and it has been made and remade so many times during the past 40 years, that it required boldness to venture to Vienna, but there they were, and notwithstanding that they were not equal to what may be seen at Woolwich, still many evidences of latent ingenuity are manifested, and 30 years ago all their productions, and the means of producing, would have been deemed first class. One striking feature in the working of this plant was the employment of girls instead of lads, and there is no good reason why it should not be so, if all are agreed; it is done in Birmingham, and for light work succeeds very well. The action of these several machines consisted, as usual, first in the cutting out of the disc, and then its formation into a cup (but here the two were performed at one operation), then by the ordinary means the cup was elongated into a tube, closed at one end, the changes of form inducing change of mechanical structure of metal, thus involving annealing, but the ultimate effect was in the metal being drawn over the spindle in the same manner as a piece of dough might be drawn over the finger. There was likewise a machine for equalising the edges of planks as they are cut from the tree, and which could (at the will of the attendant) be regulated to any width to suit the plank, and yet without stoppage. The machine consisted of two circular saws mounted upon one spindle, but with one of the saws on a socket and adapted to slide on the spindle within a considerable range, thus admitting of the two saws being at different distances apart to cut to any

width; this was considered to be very good, was said to be quite new, and it worked most admirably.

T. Munktell, of Eskilstuna, made a very fair show of small tools much resembling the American type in almost every feature, indeed so closely were they imitated that the first impression was that they were American and not Swedish. The lathes, drilling machines, and especially the drills, were very good in regard to workmanship, but this however is the only point to be conceded.

Sweden could not do better than instruct her youth to imitate the refined American workmanship, which will be a harder task than the teaching of engineering, unless it comes naturally. Altogether the Swedish display, although not large, was full of nice points that had a freshness about them not always to be met with, and that country will have no cause to regret her display made at Vienna.

Germany.

In consequence of the vast extent and grandeur of the display made by Germany it will scarcely be possible to do more than summarise a few of the leading classes of articles.

The firm of Kamp & Co., of Westphalia, put forward a 15-ton Nasmyth hammer, which has been in constant use since 1862; it is certainly a handsome tool, and there is good excuse for a little pride regarding it, it weighs 50 tons above the anvil, which latter weighs 150 tons. The lower part of the hammer structure consists of two columns and a hollow girder in one, the girder forming a kind of entablature to the columns, the whole of this part was made of wrought-iron. Above the girder are the two distance pieces, which likewise act as guides to the piston and hammer, these distance pieces are made of cast-iron, and are surmounted by the cylinder. Alongside the hammer there was a splendid show of chilled cast iron rolls of all sizes, the largest being three feet in diameter by 10 feet in length, they were cast hollow, the metal was as hard as it can be made, the rollers were turned and polished into a surface like burnished steel, and they were really magnificent. There were other steam hammers exhibited, but the one above referred to attracted the greatest attention.

The grand collection of machine tools submitted by John Zimmermann, of Chemnitz, was a treat to behold, many of the castings were real works of art, and the workmanship was exquisite. The designs of the different machines were generally like those of the best English makers. As founders

they may certainly be ranked with the best, with all the brackets cast upon the greater structure, and produced in a manner that is simply perfection. As an executive establishment, this house is not to be easily surpassed. One of their most striking machines was that for planing the teeth of large bevel wheels to the true mathematical lines, and which they very properly quoted as "Hunt's system," but the design of the actual machine here referred to was made by another English firm which did not quote the words "Hunt's system." The veneering machine was a grand tool, and so was a Nasmyth hammer on "Naylor's system." Their punching machine was fine in the general outline, but the main wheel was out of all proportion, the arms especially, and the teeth, rim, and centre were all full of inconsistency, both in proportion and character.

Another great firm, almost of the same standing as the preceding one, was that of R. Hartmann, of Chemnitz. They exhibited some very good tools, and mostly upon the English system, still there were some original ideas exhibited, well conceived and carried out, and some others not quite so good. An exceedingly well-contrived apparatus was that for turning the crank-pin upon the face of the railway wheel or upon the common crank, the said pin being forged in the solid (instead of in the usual mode by insertion), which seems to be in the right direction. In this apparatus, the instrument or tool-holder is a box on the end of a sort of spindle, but the steadiment of the box in turning the important part of the crank is derived from a true fixing upon or concentric with the crank-pin. This was very good. A lathe for turning railway wheels upon their axles was scarcely in good proportion, a large quantity of metal was wasted in the construction, a good fault no doubt, but a firm which makes such a display should aim at consistency. A strong wall boring machine was a credit to the firm, it was in better proportion, and yet of sound construction. Taken altogether, the best united collection made by any single town in Germany was that of Chemnitz, which will in time become a second Manchester, a fact that is not due to chance, but to causes as certain as gravity.

There were other two Chemnitz houses that made a good display, namely, Constantin Pfaff, and M. Limbach; the tools of the former were very high class, and the screw-cutting lathe of the latter was a really good tool.

There were likewise a considerable number of other machine makers, whose products were more common place, and some of very defective construction in regard to design

and proportion, and in the quality of the iron employed. On the other hand it must be said for Germany that some of the best houses have the secret of mixing the metal as well as the best to be seen anywhere. The quality arising from our mixture of Scotch with white, remelting, and selecting, is secured with other brands, and the result is just as good, and so near, that even an expert could scarcely perceive the difference.

The Vulcan Works, of Chemnitz, likewise made a good display of machine tools for metal, but with no special points of interest.

G. Kneisel, of Chemnitz, exhibited an enormous smith's vice, intended to be used as an anvil, it was certainly a fine specimen of good, sound, honest workmanship. A plant of wire-drawing apparatus was also shown, but it was of a rough character; the wire made, however, was good, as depending upon the draw-plate rather than on the machinery.

There were two firms from Offenbach, each of which made a decidedly good impression, and probably they are the best houses in Germany, although they did not make such a display as those of Chemnitz. One of the said firms is Collet and Engelhard, and the other firm is Schmaltz Brothers; both have the proper spirit within themselves, and if one did not know better, their products would be pronounced as of Manchester rather than of Germany. The former firm made a very good display, but the latter more particularly so, and which was characterised with a freshness and freedom of practical utility that is rarely to be seen on the continent. This latter house is famous for sawing machinery, but their frames contained no essential features different from our own. They exhibited a good simple tenoning machine, and the sensible double disc arrangement, whereby the action of the cutters in their moulding machine can be reversed, in order to prevent the ends of the mouldings from being injured, and thus keep them intact to the extremity, was very ingenious but yet simple. The system of reversing by the two discs is not sufficiently taken advantage of, probably it will be more so in the future, judging from its having been many times shown at Vienna, and especially by Deny of Paris, and by Messrs. Schmaltz.

Probably the largest and most perfect machine ever constructed for cutting the teeth of wheels was exhibited by the firm of L. A. Riedinger, of Augsburg. Of late years, the erection of immense water turbines to give motion to factories requiring a thousand horses' power or upwards, has led to the introduction of a style of millwork gearing far in

advance of that erected in the olden times. As this modern style of gearing revolves at great speed it is advantageous to have smooth working gear (even with metal to metal) in the teeth of the wheels, which practically cannot be obtained without a high degree of refinement in all the lines, and in the precision of the pitch of the teeth; accordingly this has led to the machine now referred to, by means of which the utmost accuracy is secured by working from a copy with self-acting arrangements, the machine working on silently, tooth after tooth, whatever the length, pitch, or diameter. The principle of action was on "Hunt's system," and its execution was perfection; some of the bevel wheels were from 12 to 15 feet in diameter, and the pitch at the outside fully six inches. The tools employed were such as are used for ordinary turning or planing, two were used, and traced the bevel lines from bars at the angle, the curved lines were traced from template all combined, and the result was a perfect tooth; it did not, however, appear that the arrangements shown could cut spur wheels without modification. Some of the said millwork was very grand, and was a source of wonder to the engineering world.

The firm of Gschwindt & Co., of Carlsruhe, had a collection of machines for metal and wood generally, of a second rate quality, but there was a good deal of real novelty notwithstanding; the lathe for turning taps with the grooves upon them was made by this firm, and it was well worth an inspection. It was generally observable that the continental lathes have mostly brass bearings, even under the usual limiting line of 12-inch headstocks; possibly this is correct, for admitting that steel is the better, nevertheless, with a careless workman the ruin is not so great (after carelessness) with brass as it is with steel.

Several heavy shearing machines were shown by different firms, of a very rough, strong character, suitable for iron works; likewise apparatus for sawing rails to length when cold, as well as apparatus for drilling the ends of rails, with three drills for the one operation. Also smiths' forges with a Root's blower for each fire, which would be satisfactory from a practical point of view if it were so commercially. There was also exhibited a shaping machine driven by a worm, exceedingly smooth in its action; and a radial slide-rest-arm upon a spindle (self-acting) was very good in its arrangements, and performed its work in fine style.

The firm of Ludw Lœwe & Co., of Berlin, exhibited a few light machine tools for metal (after the American style) which were well got up in every particular, and had some

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good points for sharpening cutters, with the teeth at an angle, that cut very smoothly in consequence. They also showed a set of templates for the manufacture of sewing machines arranged on the small-arm principle of manufacture, the parts being interchangeable. Altogether this was a good show, and many found it instructive.

Carl Thomass, of Dresden, submitted a Sellers' screwing machine of careful workmanship. Elkan and Wolff of Berlin had a very good lathe, with a combination of tools for screw-making possessing some nice points to insure precision. W. Tietzsch & Co., of Berlin, had a few tools of the lathe and plane class, but they were inferior to those of Saxony. G. N. Justus, of Hamburg, likewise sent a few tools, but of common description. An immense show of screwing apparatus of fair workmanship, was submitted by J. E. Reinecker, of Chemnitz; and Aug. Wolff, of Walsrode, Hanover, exhibited a plant for cask making, with the cylindrical saw and all modern appliances, which seemed to answer the purpose satisfactorily.

A very effective nut-making machine was shown in action by Nicaise, Gobert & Son, of Westphalia, the furnace was outside, the red-hot iron was handed through a hole in the wall, and the manufacture of nuts went on steadily. It is encouraging to observe such earnestness of purpose as that shewn by this firm.

Nestler & Breitfield, of Schwarzenberg, exhibited a very superior nut-drilling and screwing machine, arranged vertically. This machine is much liked in Germany, and it performed its work very rapidly.

The firm of Kneusel, of Reuss, made a splendid show of tools after the American system; they were for all purposes in connexion with the trades that work metals in the thin state, tin plate, sheet copper, zinc working, and such like. They consisted of machines for cutting, bending, turning over edges, and for many other purposes, and as a whole were very well got up as machines, and made really good work. There were two other extensive collections of similar tools exhibited by A. Lismann of Munich, and R. Spitzner of Leisnig, all very advanced, and in this department Germany is second to no country.

The firm of A. Esterer submitted an excellent machine for making stone or iron columns, it was constructed on the planing principle and was adapted either for what may be termed turning, in order to produce plain surfaces, or for fluting in straight lines, the groove depending for shape upon the cutter, or it could be arranged for spiral fluting

by simply combining the motion of the stone with that of the plane, thus forming a screw. Our stone workers ought to take this machine into their serious consideration, as it is a thoroughly practical tool.

Germany came out strong in every variety of miscellaneous machinery. Sievers & Co., of the Humboldt Engine Works, exhibited a rock-boring machine worked by compressed air, the drill giving from 250 to 300 blows per minute and turning round between every blow. They had likewise an adjustable boring machine that could be set to bore horizontally at any angle or at any level within the limits of the apparatus. The air pressure used for all their machines ranged from 25 to 30 pounds on the square inch. These machines are extensively employed in the coal mines of Germany. They employ a sort of lathe to straighten the drills after working; the end of the drill is held in a chuck and unsupported at the cutting end, a kind of anvil slides upon the lathe bed, upon which, by means of a hammer, any swing or bend or want of truth is removed with facility. There were likewise some good brick-making machinery, machines for disintegrating materials on Carr's principle, ice-making machines, and apparatus for soda-water manufacture. In tobacco machinery especially Germany showed in the front rank; the plant of F. Flinsch, of Offenbach, was beautiful in its results, both in cutting the leaf and in packing the tobacco into retail paper cases; a revolving table with intermittent action was employed, there were four receptacles, one for filling, two for pressing, and one for ejection. Of course each hole is used in succession, two girls were in attendance, and the out-put of one machine was 6,000 parcels daily. This machine was well worth inspection by those who are interested in such matters.

This short report can convey but a very imperfect idea of the vast amount of wealth of mechanical apparatus that Germany in her greatness had gathered together at Vienna; indeed, so very many things were shown that a volume would be required to do them justice. Germany, as a country, is truly in earnest, and we have every reason to anticipate, that in time her people will prove themselves to be most powerful rivals to ourselves, even in some of our own specialties.

Austria.

As might have been expected, Austria, after incurring the enormous task of organizing and erecting the Exhibition,

did its very best towards furnishing its own section with the cream of its own products.

In going round the Austrian department the most cursory observer could not help feeling amazed at the quality of the Bohemian castings, and still more so with the beauty and goodness of the Styrian forgings. A nation with such a supply of the elements of machinery has every facility for becoming great in engineering, if so be that machine making is in accordance with the natural aptitude of the people. That Austria has not only the desire but the ability to become an engineering and machine-making country was clearly shown by this Exhibition, and the united gathering was, as a rule, both high in quality and prodigious in quantity.

Reference has already been made to the grand display of Carl Pfaff, of Vienna; the exhibit of that firm contained almost every kind of machinery employed for working wood and metal, including a powerful steam hammer; but the most striking feature was the character of the rudimentary castings of which the machines were severally composed. It was real art founding both in regard to metal and mould irrespective of the designs, which were likewise admirable, and altogether were not to be readily surpassed by those of any firm in any other country.

The exhibit of G. Topham, of Vienna, was likewise of a high class, chiefly in wood machinery, well designed and characterized by great strength, and showing some earnestness to attain great execution; but the machines wanted the severe grandeur and simplicity which the similar articles shown by Carl Pfaff possessed, and who was only excelled in that respect by the celebrated lathe from Buda-Pesth. That Austria should throw so much of high art into her productions without any attempt at ornament, or other extraneous assistance to secure effect, clearly shows that it must be inherent in the people. There were on the other hand many of the Austrian firms which did not come up to the same high standard as above referred to, Escher, Wyss & Co., for example, made a large display, but the designs were imperfect, the workmanship was second class, and the teeth of the wheels were not what they ought to have been. Likewise the firm of Schultz and Goebel had some forge apparatus, large steam hammers, the structure of which was composed of cast and wrought-iron, but the proportions, and especially the artistic harmony, were not equal to the occasion. Their self-contained steam shearing machine also, although very strong, had not the metal so well distributed

as was the case in some other machines of the same class. On the other hand, the hammer shown by His Imperial Highness the Archduke Albrecht was simply superb, at the same time so open for adjustment, and with every ounce of metal just in the place where it ought to be (which condition of itself always affords real beauty), that the hammer was a treat to look upon.

In the same group was exhibited a vertical saw frame of noble proportions, probably as fine as anything ever made of its kind, and evidently got up for the Exhibition regardless of expense. Ruston & Co., of Prague, had likewise a fine vertical saw frame, the chief feature in which was the interchangeability of the saws, one set could be taken out, and another set put in, with but a small amount of trouble, this was as it ought to be.

The firm of H. D. Schmid, Simmering, Vienna, had a good planing machine most carefully got up. Another firm had a wood planing machine on an entirely new arrangement; the table was circular and annular, some 12 feet in diameter, and with two planes, the intention being to have continuous action by the mere shifting and refixing as the table turns round. Much ingenuity was expended on this machine, and possibly it may work admirably; but still it is doubtful whether practically it is in the right direction, if only for the reason that it is necessarily expensive, and there must be a good deal of waste with such hurried manipulation.

An uncommonly good power hammer was shown by W. Schwabe & Co., of Vienna, constructed upon the coach spring arrangement, which really answered the purpose very well, and much better than some others shown upon the leather strap system. The same firm had a good lathe, and a screwing machine; a very remarkable peculiarity in the latter was the reversion to the now almost obsolete screw plate in lieu of the more modern dies; whether right or wrong this firm had adopted the plate from choice, and certainly the execution was marvellous in regard to quality and also to rate of production. The screw plates were carefully made, and consisted first of the screwed hole in the centre; secondly, with four smaller holes situated about one-eighth of an inch from the screw, and then connected by angular incisions for cutting the shavings and allowing them to pass outwards. The test for this class of instrument is not the mere screwing at an exhibition, where the instruments are of course perfect, but rather will depend more upon their maintaining correct dimensions and quality in the continuous

work of the factory, still it is worth a trial, at least for screws that are not required to be of the highest standard.

D. A. Bauer, of Prague, showed an ingenious arrangement of circular saws for cutting roof shingles; these pieces of wood are made with one edge like a hollow V, the other edge being the opposite but made to match and fit. These shingles were cut very cleverly by the saw being at the proper angle, and were capable of adjustment for any other angles; skew wheels were the medium employed to give motion to the saws. A very sensible arrangement was shown in some of the Austrian machines, where sharp or sawing instruments are involved, namely, in having a detent to fall into the fast pulley when the strap is moved on to the loose pulley, and which has to be lifted and folded back before the machine will go on, this will render the adjustments much less dangerous for workmen than is the case with the ordinary arrangements.

There were exhibited an immense number of the old fashioned class of tools, including lathes and such like, more especially by E. Esslinger, of Vienna, and J. Hipp, of Vienna, each of which firms made a great show. This class of tools are used by jewellers and in a variety of other trades all through the Austrian empire.

In miscellaneous articles this department was a treasure of riches, of some of the more prominent may be named a machine for perforating thin plated sieves for coffee, colanders and other purposes; the holes are punched in a spiral from the centre, a number of punches are employed, and likewise a number of plates are punched at one time, hence the rate of progress is in proportion. This was a really good tool.

A neat arrangement for chucking small articles, where a number of the same class have to be dealt with, was to have the chuck rather long, in order to get elasticity when sawn up to the rear end; a collar was the gripping agent and was actuated by a lever with the left hand, and so handy was the workman that more than 10 articles were chucked, brought to form, and removed within one minute. A rather clever machine was shown for removing the teeth from old files, the files were made red-hot and held against a circular cutting instrument, the pressure being obtained by the foot of the operative.

Some good rolling mills were shown by the firm J. Pacher, of Vienna, the rolls were very fine but the machinery was common place. A grand display of hydraulic presses for wine making were shown, as well as the other sorts of

apparatus necessary for the various operations, all in the most modern style of engineering. W. Pittner, of Vienna, showed a finely constructed coining press, it was worked on the two-disc system, as used by Deny, of Paris; this press although very good was not so grand as that exhibited by Deny.

Seyss & Co. of Vienna, showed a very ingenious machine for examining and sorting money, a good deal after the principle first applied by Mr. D. Napier, of London, and still made extensively by that firm, but in the Austrian machine there were 10 weighing beams, and each divided their share of the money into six sorts, good, bad, heavy, light, very heavy, and very light. The machine was beautifully constructed but its accuracy was not tested.

The firm H. Heusser, of Pola, exhibited a machine for cutting irregular screws or of a continual varying pitch, and with the nut so contrived that it adapted itself to all pitches, the thread spaces of the nut being short and free to move round, hence they adapted themselves to the varying circumstances of their position.

The firm H. Lewicke, of Vienna, submitted a number of artificial grinding stones, with every sort of grit that is required in the practical arts, and of any degree of porosity or sharpness to suit different metals.

The Austrian machinery exhibit taken as a whole was magnificent, the most strenuous exertions must have been made by the whole people of that great country, and notwithstanding the trouble and expense which they have incurred, and even the sacrifice which they must have made, yet the good effect will ultimately be more than commensurate, and when considered merely in its commercial aspect it will yet turn out to have been a most profitable investment for the whole empire.

Russia.

The great Russian Empire has not hitherto been reckoned amongst the machine making nations, nor is it likely to become a formidable rival for some time to come, still it has to be observed that the seed is now being sown which may in the course of another generation grow up into an abundant harvest. Although the few specimens that were shown at Vienna all point in the direction of the future, yet we may safely anticipate a steady advance at each succeeding International Exhibition.

The Technological Schools of Russia showed some very fair tools, entirely the produce of the students and their instructors, the workmanship being quite passable and decidedly creditable. Some of the tools shown were strictly after the Whitworth school, and to the honour of Russia they are honestly inscribed in the catalogue as the "Whitworth system," which was right and proper, and detracts nothing from the credit of Russia, on the contrary, it increases our respect and inspires confidence. Among the collection of machine tools was an 18-inch slide lathe, a good sound serviceable article, which would be a credit to any country. It was perhaps a little too highly decorated for utilitarian critics, but that is perfectly excusable in a production coming from a school. A six-inch foot lathe on the other hand was scarcely up to the required point of refinement in regard to those essential conditions that afford correct turning and boring, as for example, the collar; a little more patience with the grinder upon the spindle surfaces would be advantageous, but the necessity for such refinement is difficult to teach or to learn.

A small shaping machine, to be worked by hand, was well made in all respects, likewise the band saw and the wall drilling machine, both were very fair, and good enough for any ordinary work. The shell moulding table however was not so good either in regard to design or workmanship, indeed the latter was rather rough, and as regards the former there are many better things for the purpose to be found nearer home but which are not deemed worthy of a place at an exhibition, and which is quite right when taken in connexion with our collateral superabundance of better things which might have been forwarded, if like Russia we had done our best.

Although the display of machinery made by Russia was not large, nor yet contained very much that was either novel or striking, still it had a noble model of a 50-ton steam hammer and steam crane combined, which was as unique as anything of the kind yet exhibited to the world, and although it was only a model that was thus shown, still it was probably as large as an ordinary five-ton hammer; and even to convey this model from Russia to Vienna was no light matter. The hammer itself however must be a grand sight, and judging from the model and from the drawings which were freely given away, it could be seen that every detail of the structure had bestowed upon it the utmost deliberation and careful study, and that it was constructed

quite regardless of expense. With the exception of the foundation plate, the cylinder part of the apparatus, and two standards, the structure is built up entirely of wrought-iron with plates, angle iron, and riveting. There is, first, the cast-iron foundation plate surrounding the anvil; secondly, two main standards which terminate in an entablature by which they are united into one great wrought-iron structure. The entablature being hollow it thus envelopes the hammer when at the bottom and resting upon the anvil, the only parts seen being the removable parts both of hammer and anvil. Upon the entablature there are erected the two guiding standards or distance pieces, which are thus comparatively short and stiff, and upon which is fixed the cylinder with its numerous appendages, the whole structure reaching to a height of 50 feet, and the weight to nearly 500 tons. The wrought-iron steam forge crane rests upon the foundation plate, and is supported at the upper end by a wrought-iron angular fixing, which is connected to a prolongation of the foundation plate. The steam engines are within the sides of the crane and receive the steam and exhaust pipes through the upper pivot, which is hollow. The crane arrangements in other respects are of the usual character with strength in due proportion. This probably is the most gigantic Nasmyth hammer ever yet constructed, and any country might feel proud of having contrived and combined such a majestic piece of working mechanism. The Russian mechanics are capable of becoming good workmen, and may yet play an important part in machinery construction.

In conclusion it may be asked what is the great lesson taught to ourselves by the Vienna Exhibition? It shows us clearly and certainly, that in regard to the classes of articles which are referred to in this report we have henceforth no monopoly in them, and that our success in the future will entirely depend upon the united co-operation of capital with both thinkers and workers, with each in his own place doing his utmost to refine and improve our productions, and in the devising of better auxiliary means in order to produce them more and more rapidly and economically. If therefore we are wise and earnestly resolve to do so as a united people, then we may still be enabled to secure our fair share of the material advantages which are to be derived

therefrom; but if on the other hand we are disposed to rest upon our oars as thinkers, and if at the same time our workmen do not see that it is their duty and to their self-interest to aid heartily in the cheapening of production, we may rest assured that other nations, which may be wiser in their generation, and therefore act more sensibly, will gradually step in before us and reap the harvest which was sown by our fathers, and that the rich inheritance bequeathed to us will slip through our fingers imperceptibly but certainly, and most probably for ever. It is for us to choose now, for if we wait until the brink of the precipice is in view, it will then be too late.

The changes that overtake nations, are due to the effect of natural causes previously existing and acting on the minds of society generally, and are as definite in their ultimate result as the ordinary laws of nature. There are well authenticated instances of trade having shifted its locality in direct consequence of the unwise conduct of individuals, who were not acquainted with the principles of political economy. It is, therefore, most desirable that every boy before leaving school should be well grounded in some of the elements of that branch of knowledge in order to keep us right, as a nation, in regard to the vital questions that are involved in the solution of the problem here referred to, and on which the permanence of our machinery trade necessarily depends.

We likewise require a larger diffusion of high class scientific education, in combination with thorough training in the technological branches of knowledge that bear on each several specialty, not only for workmen, but more especially for foremen, draftsmen, and managers, and still more so for masters; nothing less will place us upon an equality with the rising young men of Germany.

This therefore is a serious matter, requiring the immediate attention and deep consideration of all who take interest in the future welfare of Great Britain.

MR. G. C. V. HOLMES.

STATIONARY AND PORTABLE ENGINES.

Report on the Objects of Exhibition in Group XIII., Class I., comprising Stationary and Portable Engines and Boilers, Steam Pumps and Fire Engines, Hydraulic Motors, and Hoisting Machinery.—By G. C. V. Holmes, Esq., Whitworth Scholar, Member of the Austrian Institution of Engineers and Architects.

Classification and object of this report.

It is not proposed in this short report to give a detailed description of the numerous objects of exhibition classified under the above heading; such an account would necessarily involve a great expenditure of time, for many of the objects were not new, and much injustice would moreover be done were such an attempt made, since the limits of this report are far too small for such a purpose. It is intended, on the other hand, after passing a few general remarks on the work of the Jury, and the progress indicated in this section of the Exhibition as a whole, to single out some of those inventions or applications of sound scientific principles which would seem to be landmarks in the progress of mechanical science, and which are worthy of imitation in our own and other countries.

The work done by the jury.

The work of the Jury, as far as it went, was, I think, carried out with fairness and discrimination. All those exhibitors who obtained the Grand Diploma of Honour undoubtedly deserved this high distinction, while the claims of no one were neglected. It will be understood that reference is only made to this special section of the group.

Embarrassment of the jury in awarding prizes caused by the regulations of General Direction.

The regulations of the General Direction concerning the value to be assigned to the different medals caused great embarrassment, and rendered doubly difficult the task of rewarding each exhibitor in proportion to his merit. These regulations enacted that all the rewards, with the exception of the Diploma of Honour and the Honourable Mention, should be considered as of equal value. Of these rewards two only, viz., the Medal for Progress and the Medal for Merit, come within the sphere of operations of Group XIII.; the other two, viz., the Medals for Good Taste and for the Fine Arts, being evidently not applicable in an exhibition of mechanical engineering. The fact that the two first-mentioned medals were of equal value, rendered it impossible

to recognise more than three degrees of merit, and as the reward for the highest of these, viz., the Grand Diploma of Honour, corresponded to a Council Medal, to be awarded in only a few very exceptional cases by the Council of Presidents, it is manifest that the means at the disposal of the Jury were very inadequate to reward with anything like justice the varied degrees of merit which always present themselves in an exhibition of this nature.

Resolutions of the group jury.

Where, as in Group XIII., a Medal for Good Taste can find no place among the awards there remain but two Medals and an "Honourable Mention" to distinguish the relative merits of so many various machines. The Jury endeavoured to carry out the intention of the General Direction in awarding the Progress Medal where any progress was perceptible, and the Medal for Merit for objects which, though excellent in construction, laid no claim to novelty or improvement. This was no easy thing to do through the inevitable tendency to regard the one medal as a higher award than the other, and the difficulty in accurately defining the word "progress."

Suggestions for the future.

It may perhaps be suggested that if the Vienna system of rewards be adhered to on future occasions, the creation of two classes for each medal—such as a first and second class medal for merit, &c.—will prevent any ambiguity, and will greatly simplify the work to be done.

Work left undone by the jury. Trials of engines and boilers.

Before going on to notice the Exhibition and its contents, I cannot help expressing a regret that the Jury of this section did not undertake the task of putting all the stationary engines and boilers which were at work through an exhaustive trial, in order to test the ratio of fuel consumed, first to the water evaporated, and then to the indicated horse-power developed. It was proposed to undertake a trial of this sort, but the proposition was rejected on the ground that there was barely time enough to finish the work which was actually on the programme; but if due notice had been given to exhibitors on the first announcement of the Exhibition, the work might have been got through, with the aid of a carefully-selected staff of experts, in the limited space of time which a Jury naturally enough has at its disposal.

Advantages of such trials.

It is a great pity that the opportunity could not be utilized, for never before were there such a number of different types of engines and boilers simultaneously at work, and the testing of these under similar conditions would have furnished us with a set of results of immense importance both to the scientific and commercial world, and would have served as a landmark in the history of mechanical progress, and a starting point from which to date new improvements. If any one doubts the

value of such periodical experiments he has only to study the improvements in portable engines which date from the institution of the competitive trials of the Royal Agricultural Society, or the similar progress in marine engines chronicled by Mr. Bramwell in a paper read before the Institution of Mechanical Engineers at Liverpool in 1872, from which it appeared that in the year 1863, when the first inquiry was made by the Institution, the lowest consumption of coal in the best Atlantic steam-ships was 4½ lbs. per indicated horse-power, whereas in 1872 the average consumption of 17 compound engines was only 2¼ lbs., and even better results have since been obtained.

Present awards not wholly satisfactory.

As things are at present arranged, Juries give their opinions on, and award prizes to, different engines and boilers without having an accurate personal knowledge of the performances of each, and though their judgment is in most cases correct, yet some injustice is unavoidable.

Suggestions for future exhibitions.

In the hope that the organisers of the Great International Exhibitions, which are already casting their shadows before, may recognise and remedy defects which mar their usefulness, I will here give a short account of how these trials ought to be conducted, and should further information be wanted reference can be made to an admirable account of such a trial contained in the number of Engineering for Nov. 3, 1871, on which account indeed the following hints are largely based.

Objects of trials.

The objects to be kept in view during the experiments are :—

1st. To determine how much water is evaporated in each boiler per lb. of fuel burnt.

2nd. How much steam is used in each engine for every horse-power developed.

3rd. To account for the disappearance of all the heat generated by combustion; and,

4th. To discover all the faults in the design and workmanship of both engine and boiler.

It would probably require a whole working day of ten hours to carry out the experiments on one engine and boiler.

Method of finding out consumption of fuel.

To determine the qualities of a boiler, it should first be kept at work for some days previously, in order that the brickwork may be thoroughly warmed through; then on the morning of the trial, after steam has been got up, and the water level and steam pressure carefully noted, the fires should be withdrawn and the furnaces charged again from a weighed heap of coal of known calorific power. Throughout the whole day no other fuel should be used, and in the

evening, on the termination of the trial, the water level and steam pressure having been again noted, the fires should be finally withdrawn and be set aside to cool. When the cooling is effected, the good fuel should be separated from the clinker and dirt, and each be weighed separately, as also should the contents of the ash pit and the remainder of the original heap of coal. From the figures thus obtained the actual quantity of fuel consumed may be deduced.

Feed water.

In the meantime the feed water delivered into the boiler should have been carefully measured, and the temperature if variable should have been noted at regular short intervals throughout the day. The feed pump should be supplied with steam from a separate boiler in order not to interfere with the results we are seeking for, and care should be taken that no steam leaks from the boiler under trial into any adjacent boilers with which it may be in connexion.

Determination of water evaporated per pound of fuel burnt.

Having determined the weight of water evaporated, we can at once settle the ratio of this quantity to the fuel actually consumed. We shall afterwards see how to find out whether all this water was really converted into steam, or whether part of it was carried over by priming into the engine.

Amount of heat wasted in boiler.

Knowing as we do the theoretical evaporative efficiency of the coal and also the weight of water actually converted into steam at such and such a pressure, we can by expressing both quantities in standard heat units and comparing them, see at a glance how much of the heat of combustion is wasted on account of imperfections in the boiler.

To find out where and how heat is wasted in boiler.

We ought also to seek to determine where and how this heat has disappeared, and for this purpose the temperature and quantity of the gases should be taken as they leave the boiler flue, or the economiser in case there is one, and numerous samples should be taken for analysis.

Inferences to be drawn from comparative trials.

If all this be done, and if the dimensions and peculiarities of each boiler be noted down and tabulated, we shall be able at a glance to infer why one is a better evaporator than another.

Heating surface.

For example, if in any case the results be not good and the temperature of the issuing gases be too high, we shall know at once that there is either too little heating surface, or else that what there is is not efficient, which latter fault may perhaps be due to a deposit of scale or mud over the crown of the furnace caused by the absence of any means for promoting circulation. On the other hand, if the issuing gases

Smoke and carbonic oxide.

have a low temperature and the evaporative efficiency be still inferior, while the results of analysis prove that the gases contain carbonic oxide and hydrogen, it is a sure sign that

the furnace is not properly shaped, so that air in sufficient quantities cannot get to the fuel, which consequently, instead of being all converted into carbonic acid, is partly turned into carbonic oxide. This state of things makes the greatest possible difference in the results obtained, when it is considered that one lb. of carbon, when converted into carbonic acid, gives out 14,500 units of heat, whereas converted into carbonic oxide the same pound of carbon only generates 4,400 units.

Cause of the formation of carbonic oxide and loss of hydrocarbons.

The rationale of this process of waste would seem to be as follows:—When the furnace is supplied with air which gains access to the fuel only between the bars of the grate, the free carbon is first converted into carbonic acid, and the heat thus evolved volatizes the hydrocarbons contained in the coal. These latter are raised to a high temperature, in which state it is known that most of the carbon contained in them is disengaged in the form of a fine powder, and the greater part of the hydrogen is set free. On issuing from the top of the layer of unburnt fuel, where there is no special supply of oxygen to burn them, the temperature of these gases is cooled down, and the powder carbon floating about forms soot, while the carbonic acid gas on issuing from the fuel takes up from this smoke additional carbon in sufficient quantities to convert itself into carbonic oxide. Thus we have for the products of combustion in extremely bad cases a mixture—of smoke, i.e., pure unburnt fuel;—of carbonic oxide, or partially burnt fuel;—and of hydrogen, a very powerful fuel, utterly wasted.

Composition of furnace gases when combustion is imperfect.

Low temperature of gases in chimney is often a sign of inefficiency.

On the other hand, the low temperature of the gases in the chimney may be due to an excessive supply of air to the furnace, the consequence of which is that the hot gases are diluted by useless matter, their temperature is cooled down, and the rate of transmission of heat through the heating surface is diminished: for this rate is due, as is well known, to the difference in temperature between the two sides of the surface. Consequently, although the fuel may be thoroughly burned, its heating effects are diminished. These are just three instances of the way in which peculiarities of the boiler affect its efficiency, and are mentioned here in order to show the method of working, and the value of this system of comparative testing, for it is only when we have all the data of each boiler arranged in a tabular form, that we shall be in a position to form correct inductions, and so determine why this or that example gives better or worse results than any other.

Determination of all other quali-

When these data and the dimensions of each boiler are given we shall be in a position to determine all its other

ties of boiler by means of trials.

qualities, such as, water evaporated per square foot of heating surface per hour, fuel burnt per square foot of grate surface per hour, &c.

Heat utilised in engine.

We have next to determine how much of the heat contained in the steam is utilised in the engine, and the trials to determine this point should of course go on simultaneously with those described above. In the first place indicator diagrams ought to be taken at regular intervals of half an hour throughout the day, and that too simultaneously from both ends of all the cylinders. A counter should also be attached to the engine, in order to register the number of revolutions actually made in the day. This number multiplied by the average power developed in a single revolution gives the total actual power exerted in the day.

Indicator diagrams.

Precaution to be observed when taking diagrams.

Care should be taken that the work to be done by the engine is kept as uniform as possible, for otherwise the average of the diagrams taken would not give the average power developed during each stroke, and the accuracy of the whole trial would be marred. If it be impossible to keep the work uniform, there is no alternative but to make use of a continuously recording indicator.

Treatment of diagrams.

Assuming, however, that it be possible to work with the ordinary indicators, all the diagrams taken during the day should be computed after the trial, and the average of the power developed should be determined. Some one set of diagrams should then be sought for amongst the whole number taken, which as nearly as possible represents this average, and this set should be preserved as the representative diagrams of the engine in question. It would be of great use if this set were transferred to cards on which were previously drawn in a different coloured ink the true theoretic curves of expansion for the given pressure and ratio of cut off. The nature of these curves would of course depend not only on this pressure and ratio of expansion, but also on the circumstances of the cylinders: for instance, a perfectly lagged cylinder would give a true adiabatic curve, or line of no transmission of heat, either into or out of the cylinder. A jacketed cylinder on the other hand would give another curve, the shape in this latter case depending on the rate of flow of heat from the jacket to the cylinder, and this rate is a complicated function depending not only on the initial difference of temperature between the contents of the jacket and cylinder, but also on the amount of heat lost by the steam in doing work, in radiation through the unjacketed piston, &c., &c.

Comparison of actual with theoretical diagrams.

Jacketed and un-

In practice it will chiefly be found necessary to determine one nature of curve, viz., that due to a cylinder jacketed

with steam direct from the boiler, for it is probable that few but jacketed cylinders will be entered for a competition of this sort. It would, however, be extremely useful in order to determine the real value of a jacket, to try some of the engines wherever it is possible to do so, first with the jacket full of steam, and secondly empty. Jacketed cylinders.

If the diagrams be treated in the manner suggested above and the actual and theoretical curves be compared, we shall be in a position to know everything that is going on within the cylinders; for example, we shall learn not only the usual lessons to be obtained from indicator diagrams, such as the power actually developed, the amount of expansion, the effects due to clearance, the action of the valves in admitting and cutting off the steam, in cushioning, &c., the perfection of the vacuum, but also we shall be able to tell whether steam is leaking from the boiler, through the valves into the cylinder or through the piston into the condenser, and if such leakage occur we shall often be able to determine its amount; moreover we shall know whether steam is being condensed at the commencement of the stroke and re-evaporated towards the end. In fact there is scarcely a disease to which the engine proper is subjected that cannot be revealed graphically by this method of looking at a diagram. Inferences to be drawn from diagrams.

Before quitting the subject of the indicator it is as well to suggest that friction diagrams should be taken of the engine when running light, for from these we shall be able to appreciate the effects not only of good workmanship but also of good design in increasing the net amount of horse-power delivered per unit of fuel burnt. For instance, we should probably have found a great difference in this respect between the now fashionable single-cylinder Corliss engines with their heavy fly-wheel, and enormous pressure of steam let on to the pistons at the dead centres, thus inducing great strain and consequent friction on the main bearing, and the beautiful compound Ehrhardt engine, exhibited in the German department by Dingler, of Zweibrucken, with its two cranks set in one line, thus minimising the pressure of the steam on the bearings, its comparatively insignificant fly-wheels, and its freedom from heavy reversible parts. Friction diagrams.

Leaving the cylinder and going to the jacket, if this latter be fed with steam direct from the boiler, we should keep an accurate account of its temperature, pressure, and the amount and temperature of the water which drains from it during the trial. If the jacket however contain hot air, as it is quite likely to do in small semi-portable engines, it will not be necessary to keep any special record of its temperature, for the Condensation in jacket.

examination of the gases in the chimney previously referred to, will furnish all the information wanted on this head.

Examination of condenser.

We must now pass on to the condenser, the examination of which is perhaps the most peculiar feature of this system of trial.

In the first place, observations should be taken, at very short intervals, of the amount and temperature of the water which is discharged from the condenser. The amount and temperature of the condensing water should also be recorded. The rise in temperature of this water, on passing through the condenser, can thus be ascertained, and as the quantity discharged per minute is also known, we can tell at once the number of units of heat which pass through the engine per minute. The ratio of this number to the indicated horse-power gives a result showing how many units of heat pass through the engine per horse-power per minute.

Number of heat units passing through engine per minute.

This is a very interesting number, and moreover a very useful one in practice, as it is a good test of the efficiency of the engine; for having once determined the number under the best conditions, we can always tell, by examining the number under *any* conditions, whether the engine is working true to itself or not. For instance, supposing the number to have been first determined when the engine was in good repair, any defect subsequently arising, such as leakage on the part of a valve, or imperfect vacuum in the condenser, would be at once indicated by an increase in the numerator or a decrease in the denominator of the fraction which expresses the ratio in question. It can also be used for finding the number of horse-power developed at any time by the engine, on the supposition that the original conditions remain unchanged.

We have now, however, only to do with the use of the number in this trial. Having determined it, we are in possession of the last item of waste of heat in the process of converting fuel into work; for it must be borne in mind that the whole of the heat passing through the condenser is wasted unless it be applied to heating the feed water. The difference between the heat thus lost and the heat supplied to the engine in the form of steam at a given pressure gives us a number which shows how much is absorbed by the engine itself. Of the amount thus absorbed a great proportion is, as has been shown, wasted in various ways, and the balance alone of the total heat due to combustion is converted into mechanical work.

Originators of this method of

To Messrs. Donkin & Farey is due the merit of having first made use of the above number as a test of the efficiency

of an engine. Their methods of obtaining the discharge per minute from the condenser and the temperature are most interesting, and will be found fully described in the number of Engineering previously alluded to. They have since invented an automatic system of continuously registering the two quantities by means of photography, which would be found invaluable in an extended series of trials. investigation.

These figures being all determined, they ought now to be arranged in two tables as follows:— Treatment of figures obtained in trials.

The first table expresses the waste which takes place in the boiler, and should consist of two columns, of which one expresses the heat of combustion of the fuel, and the other the way in which this heat is used and wasted.

Total number of units of heat evolved by the *complete* combustion of the fuel used throughout the day.	(1.) Total number of units of heat expended in converting the whole amount of feed water at a given temperature into steam of the given pressure. (2.) Heat contained in the gas of an ascertained temperature which passes up the chimney. (3.) Probable losses due to radiation, conduction, &c., &c.

The numbers on each side of the line should be equal, but as they never will be so in practice we must look about for the other causes of loss of heat. These will be supplied by the analyses of the gases in the chimney; from these analyses we can set down the further loss due to the imperfect combustion of the fuel, *i.e.*, to the formation of carbonic oxide gas and smoke, to the waste of the hydrocarbons, and lastly to the admission of excessive quantities of atmospheric air. Analysis of the gases in chimney.

We should next make a similar table for the engine, setting down in one column the total number of units of heat contained in the steam of the given pressure, and in the other the various ways in which this heat is disposed of in the cylinder and condenser. Table expressing waste in engine.

Total number of units of heat contained in the steam formed in the boiler and supplied to the engine during the trial.	(1.) The equivalent in units of heat of the work done in the engine. (2.) The number of units of heat wasted by condensation in the jacket. (3.) The number of units of heat contained in the water as it leaves the condenser over and above the number of units contained in the condensing water. (4.) The losses due to radiation and conduction in the steam pipe and elsewhere.

As before, the numbers on the two sides of this line should be equal, and if they are so it is a test that no water is carried over by priming into the engine. How to find out whether priming takes place.

Separate analysis of diagrams.

A separate analysis should be made of the diagrams, showing on one side the equivalent in heat units of the perfect theoretical diagram, and on the other the losses represented by the roundings of the various corners of the figure, as well as those due to the clearance spaces; to the leakage of steam through the admission valves into the cylinder, or through the piston into the condenser; to the condensation of steam at the commencement of the stroke; and, lastly, to the imperfection of the vacuum. The trial would then be concluded.

Measures necessary in order to ensure success.

It would require only a certain amount of forethought and organisation, and the judicious selection of jurors and experts in order to ensure complete success.

It would be impossible here to give all the practical hints which would tend to lessen delays and prevent failure, but in case these hints be ever adopted it should be suggested,—

(1.) That the earliest possible notice of the trials, with an exact programme and list of conditions, be furnished to all manufacturers.

(2.) That the shafting of all the countries represented in the machinery hall be so arranged that they can if necessary be coupled together.

This last is a most important provision. It would have been impossible to test the Sulzer engine in the Vienna Exhibition because there was not machinery enough in the Swiss department to keep it fully at work: whereas had it been possible to connect the shafting of Switzerland with the countries on either side of her, all would have been easy.

(3.) The trials should take place as late as possible during the season of the Exhibition, in order that each engine and boiler may have time to develop its own peculiar weaknesses, and the superintendent of the machinery department should be instructed to take note of the nature and extent of every repair executed from the date of the opening to the date of the trial, and to report the same to the Jury.

The object of this regulation would be to discourage as far as possible the use of very delicate apparatus, which though showing excellent results on trial, would fail to stand the rougher tests of every-day work in the shop.

Good to be derived from these sorts of trials.

If scientific trials of this sort should eventually form an indispensable part of the programmes of future Exhibitions, a new and wide sphere of usefulness will be opened up to these institutions, and they will become as indispensable to the cause of progress in exact and economic science as they now are to the spread of industrial arts and to the development of commerce.

What better advanced treatise on the steam engine could be found than the official report of a series of trials such as the one described above? Or what better technical education could be provided for a manufacturer than the written statement of the performance of his favourite engine or boiler, showing him (only too probably) how and why it turned out to be a machine for wasting rather than for using fuel, and consequently supplying him with the practical instruction needful, in order to do better next time? It should be the task of the commission for the future International Exhibitions, and for the various countries taking part in them, to arrange that all this be possible in future. Special value of systematic technical reports.

General View of the Contents of the Exhibition.

Turning now to the contents of this department of the Exhibition as a whole, it cannot be said that they are rearkmable in any way for striking novelty in design or principle. Absence of striking novelties.

It is very clear that the principles which were first successfully put into practice by the American Corliss are fast gaining ground in Europe: a fact which is proved by the numerous imitations and variations of the original type which are to be found re-produced all over the Machinery Hall. Spread of the Corliss engine in Europe.

The most original prime mover by far in the exhibition was the compound Ehrhardt engine, made and exhibited by Dingler, of Zweibrücken in the Palatinate, a detailed account of which will appear in the proper place. We are much mistaken if this machine does not find many imitators. The Ehrhardt engine.

Amongst the numerous modifications of the Corliss* engine, the specimens contributed by the brothers Sulzer, of Winterthür in Switzerland, and Messrs. Bède & Co., of Verviers in Belgium, are the most remarkable. The former is perhaps the finest development of the type which has yet been produced. It is fast becoming a most fashionable engine, both in Switzerland and Germany. England has a large export trade in these engines, especially to Russia. Modifications of Corliss engine.

It is a pleasure to be able to record that the British department contributed one very interesting novelty in steam engine construction in the shape of the three cylinder so called "Paragon" engine exhibited by Messrs. Brotherhood and Hardingham. It was employed in driving one of Boulton and Imray's "Helical" pumps, but its use will not be limited to such operations. For beauty of prin- "Paragon" engine.

* Drawings of all the machinery here referred to are to be found in the atlas of plates published by the proprietors of "Engineering" as an appendix to these reports.

ciple, simplicity of design, and fewness of working parts, it would be hard to imagine anything more admirable than this engine, and these moreover are qualities which were not obtained at the cost of economy, either in first cost, in maintenance, or in working. A more detailed description will be found further on.

Siemens' heat motors.

The two heat motors exhibited by Mr. Frederick Siemens, of Dresden, are quite original in design and principle, being, in fact, rotatory engines in which the direct cause of motion is the weight of a fluid continuously displaced, and so brought continuously into play by the action of heat. These engines have, however, yet only reached the experimental stage; whether they will ever get beyond it and produce a revolution in the steam engine is at present uncertain. In any case they are favourable specimens of the great ingenuity and inventive power of their designer, qualities which were recognised by the Jury in awarding to him the Medal for Progress.

Steam boilers.

Turning to steam generators, there was but little to be seen that was strikingly new. France, which at Paris contributed such a remarkable collection of boilers, was represented at Vienna by one solitary specimen of the so-called "French" or "Elephant" type. The English collection, which was by far the best, comprised specimens by such well-known makers as Galloway, Daniel Adamson, Howard, Cater and Walker, all of which, though excellent in their way, can now no longer be said to be new.

Head's straw burning furnace.

One really striking novelty was, however, the straw-burning locomobile boiler exhibited by Messrs. Ransome, Simms, and Head, which besides utilising as fuel a substance which has hitherto gone to absolute waste in many countries of Eastern Europe, furnished us also with an example of that great desideratum, viz., a simple and efficient self-acting stoker or fuel feed. This apparatus is the invention of Messrs. Head and Schemioth, the latter gentleman, who is now unfortunately dead, was a Russian engineer. The whole carrying out of the invention consequently devolved upon Mr. Head, and to him is due the credit of having brought it to a state of absolute perfection, which is sure to meet with the greatest success. The Jury very rightly awarded to this apparatus the Grand Diploma of Honour. It was, in fact, one of the solitary instances in which this award was made strictly in accordance with the original regulations on the subject. By the successful application of straw as a fuel, the use of the steam engine, and consequently also of steam-driven agricultural machinery, is now rendered possible in the great wheat districts of Hungary and Southern Russia, where on account of the scarcity of other fuel it has hitherto been very much restricted.

Fuel economisers.

The English department was further remarkable for the number of "fuel economisers," or feed-water heaters, exhibited. One of these was the well-known invention of Messrs. Green, of Manchester, while the others were, more or less, variations on this design, not differing from it in principle. Quite an impetus has been given to the manufacture of these "economisers" by the present high prices of fuel both in England and on the Continent; a fact which is not to be wondered at, for several well-authenticated instances exist which prove that a saving of 20 per cent. can be effected by their use, and that too when the boilers to which they are applied are of the best known construction. This statement is of course made on the supposition that the feed water would otherwise be cold.

German boilers.

Some of the German boilers are said to have given very high evaporative results, notably the Meyn boiler, sent by the Carlshütte, and also the specimens invented and exhibited by Julius Bergman, of Hallingen, in Westphalia. Both these, however, are complicated designs, and will probably be found difficult to keep in repair. The former especially, is a good example of the lengths to which German educated ingenuity will sometimes go, when unballasted by practical experience. It is sure in time to give endless trouble by the leakage of its countless joints, and some of its parts, requiring special means for their manufacture, could never be replaced except from the manufactory itself.

Sulzer boiler.

Messrs. Sulzer contributed the boiler which supplied the Swiss department with steam. It is of the Cornish type, but is furnished with a few of Galloway's tubes, with special means for causing the water to circulate, and also with numerous feed-water heaters.

Austrian boilers.

In the Austrian department, one set of boilers sent by the famous house of Sigl, was remarkable for an attempt at self-acting fuel feeding; in fact, this and the apparatus of Mr. Head previously mentioned, were the only two attempts in the whole Exhibition at supplying this much-wanted improvement.

Absence of improvements in steam boilers.

We noticed no apparatus of any sort for the burning of liquid fuel in boilers, nor yet for the utilisation of coal in the gaseous state, so that in reality the few roads which seem open for improving the steam boiler were practically unrepresented.

Steam pumps.

In the hydraulic department there were many examples of "direct-acting steam pumps" to be seen, especially so in England and Germany. These pumps are largely made in

England, and we have an immense trade in them on account of their cheapness in first cost.

New use for direct-acting steam pumps.

A novel application of these direct-acting pumping engines was to be seen at one of the pumping stations for the series of the Exhibition Palace and grounds. Here the engines of Messrs. Decker, of Canstatt, were employed in forcing water direct into some of the fountain pipes, so that the jets were obtained without the usual intermediate process of lifting the water up into a lofty reservoir.

No other objects in this department of the Exhibition deserve a special notice on the score of novelty; we can therefore now proceed to discuss in somewhat greater detail the collections of each individual country, and in so doing, we shall for convenience take them in the order in which they were arranged in the Machinery Hall, beginning at the American end.

America.

Incompleteness of American Section.

For reasons which need not be here inquired into, the American section was by no means so complete a success as it might have been, and hence it came to pass that the country which has hitherto always been foremost in steam engine reform was not so conspicuous at Vienna.

American stationary engines.

There were only four stationary engines exhibited, one of which from the Norwalk Iron Works was employed in driving the greater part of the shafting of the department. This was a simple horizontal non-condensing engine with Corliss framing, but nothing remarkable or instructive about it in any way.

The New York Safety Steam Power Company showed two small vertical engines. The fourth and most remarkable was sent in by Messrs. Pickering and Davis, of Portland, Connecticut. This was a single-cylinder, horizontal, direct-acting, non-condensing engine, its chief peculiarity being the absence of any bedplate or framing connecting the cylinder with the plummer blocks. The strains are transmitted through the slide bars, and a pair of stay rods connecting these latter with the plummer blocks. There are two connecting rods, the cranks being outside the two plummer blocks, and the fly-wheel revolves between them. The space here is necessarily limited, so that the rim of the fly-wheel has not the width necessary for the ordinary flat belting. To remedy this defect the rim has a deep V-shaped groove cut in it, and the belt is also V-shaped, being formed of several thicknesses of leather riveted together so as to fit into the groove. A belt, however, of the thickness which this implies would be

New system of belting.

too stiff to revolve, and consequently the V section has to be notched transversely at intervals of two or three inches all along the belt, in order to give it the necessary pliability. This system has been found to possess many good qualities.

Another peculiarity about the engine is, that the piston rod and valve spindle are formed of cold rolled iron which has never been in the lathe. The shafting in the American department was formed of this material, and very superior qualities of strength, toughness, and rigidity are claimed for it, in addition to the advantage that on leaving the rolls it is finished and never requires turning. In the American department too much advantage was taken of these qualities, for the section of the shafting was so reduced, in order, we suppose, to show off the good points of the material, that considerable uneasiness was caused by the manner in which it whipped whenever there was even a moderately heavy amount of work to be done. Cold rolled iron.

The sole manufacturers are Messrs. Jones and Laughlin, of Pittsburgh.

There are only two steam pumps shown in this part of the hall, one of which is on Earle's well-known patent, and is exhibited by the Norwalk Iron Works; it will be referred to in greater detail hereafter when describing the pumping engines shown by Messrs. Decker, of Canstatt, who are Mr. Earle's sole licensees on the Continent. American steam pumps.

America exhibits only one hydraulic motor, viz., a turbine by the Capron Water Wheel Manufacturing Company, Hudson, New York, and also but one steam boiler by Pitkin Brothers, of Hertford, Connecticut. We now pass direct to American turbine. American boiler.

Great Britain.

The stationary engines in the British department must have been a great disappointment to all those who hoped that England would have freed herself from the imputation, now too often thrown at her by Continental engineers, of being a spendthrift nation in the matter of coal and of neglecting the higher improvements which were being perfected every day in the countries round her. This imputation is to a great extent true, and comes, no doubt, from the fact that coal has, till lately, been abundant and cheap in this country. It is, after all, from lands where fuel is dear and difficult to obtain, that we should expect the greatest improvements in the economical use of steam; and as these conditions now unfortunately hold good in England, we may henceforward look for rapid progress in the design English stationary engines.

and construction of our stationary engines. It is to be hoped that we have been learning a lesson during the last two years of dear coal, which will not be lost upon us when fuel is once more cheap. However, the effects of this lesson were not developed enough to be noticed much at the Vienna Exhibition, for it must be confessed with regret that out of all the stationary engines which we showed at Vienna, one only, viz., that by Messrs. Galloway, could in any sense be called a high class one.

Uselessness of exhibiting bad engines.

It would be as well if our manufacturers would remember that they are only wasting their time and money, and incurring endless disappointments by exhibiting engines of an inferior stamp on the Continent, where the general standard of perfection in such matters is unfortunately much higher than with us, and where the engineers, if not remarkable for the originality in invention which characterises those of some other nations, have at least that higher education which enables them to appreciate and copy a good thing when they see it, and equally to reject what is worthless. It may be taken for granted that all really good objects will be sold for a high price, whereas inferior articles will in nine cases out of ten be returned to their owners.

Galloway engine.

The engine by Messrs. Galloway was a horizontal compound double-cylindered machine having its cranks set at 180°. The diameter of the small cylinder was 14 inches, that of the large one 24 inches, while the common stroke was 2 feet 6 inches. The two cylinders were bolted to a horizontal bed plate, on the further end of which the plummer blocks were cast. The crossheads worked in guides formed in this same bed plate, and there being no top guides, the construction was much simplified, and all the moving parts were quite exposed and easily accessible.

On account of the cranks being set at 180°, there was no need for an intermediate chamber, the steam passing direct from the small to the large cylinder by the shortest possible route. The two cylinders were therefore bolted as near each other as could be, just enough space being left between them for a very narrow valve chamber. The valves contained in this chamber were simple flat plates working across the ports of intercommunication. Similar valves were provided on the outer side of the large cylinder for the exhaust. All of them took their motion from a rocking shaft worked by a single eccentric on the crank axle. The steam from the boiler is admitted through a valve chest on the outer side of the smaller cylinder.

Peculiar valve-gear of Galloway engine.

The expansion was regulated automatically by the governor, the arrangement being somewhat peculiar. There was

a link attached by its bottom end to the bed plate near the axis of the main shaft in such a way as to oscillate in a vertical plane about this end. The motion of oscillation was given by a small crank, which in its turn was driven by a link attached to the crank pin of the small cylinder. The oscillating link was slotted, and in the slot worked a block attached to the valve rod, consequently the valve rod took its motion from the oscillations of the link. The block was attached to a lever worked by the governor in such a manner, that as the balls of the latter rose or fell the block was lowered or raised in the slot. Now as the link oscillates about its end the travel of the valve is greater or less, just as the block is nearer the free or the fixed end of the link. But as each oscillation, no matter what its length, is performed in the same time, it is manifest that the valve arrives at the cut-off point and consequently regulates the expansion at different periods in the stroke, depending on the position of the block. This arrangement appears to work exceedingly well.

The front covers of the cylinders are each cast in one piece with the cylinders themselves, and the whole engine is exceedingly simple and solid in its design, evidently the work of an engineer who is perfectly familiar with the practical side of his profession. We shall have more to say on the special advantages of this form of compound engine when discussing the machine exhibited by Dingler, which has already been referred to.

Among the other working British engines, were two by J. Derham, of Blackburn, and one by the Reading Iron Works. Oth Eng stat eng

There were several small stationary engines exhibited in the Agricultural Machinery Hall. Several of these were prettily got up, and were good specimens of fine workmanship.

There remains for description only the "Paragon" engine, by Messrs. Brotherhood and Hardingham, which we alluded to before. Its three cylinders, which are all cast in one piece, are set at angles of 120° with one another, their inner ends opening into a central drum or chamber which unites them all together, its axis being of course transverse to the axes of the three cylinders. This drum is just of diameter enough to enclose the crank pin disc, leaving a space half an inch wide all round it. The outer ends of the cylinders are closed in the ordinary way by cylinder covers. The following are the principal data:— "P eng

Diameter of cylinders, each = 9 inches.
Stroke = 8 inches.
Point of cut off = $\frac{2}{5}$ of stroke.

For convenience in description, let us imagine the axes of the cylinders to be all in an horizontal plane, and consequently the axis of the drum to be vertical, the crank axle will also necessarily be vertical, its axis being in fact identical with that of the drum. The crank axle will pass steam-tight through the bottom cover of the drum, and the disc and crank pin will consequently be completely enclosed in the engine. The disc is so arranged as to bear on the inside face of this bottom cover, and being pressed against it by the steam the two surfaces are supposed always to wear evenly together, and thus remain steam-tight. The crank pin is taken hold of by the three connecting rods which are attached direct to the three bucket-shaped pistons, much in the same manner as in ordinary trunk engines.

The steam pipe opens into the central chamber, and the steam has continuous and uncontrolled admission to this chamber so long as the engine is in motion. Were the steam, however, simply to act in this chamber or drum, no motion could possibly take place, for all three pistons would be pressed outwards with equal force, and equilibrium of the entire system would be the result.

But if steam be now introduced at full pressure on to the outer face of any one of the pistons, the pressure on the inner face will be balanced, and one or other of the remaining pistons, depending on the position of the crank pin, will be available to pull this latter round and cause the axle to rotate. By admitting and exhausting steam to and from the outer faces of each piston in succession, it is evident that continuous uniform rotary motion will be the result.

Valve gear in Paragon engine.

The steam admission and exhaustion for all three cylinders is regulated by a single disc-shaped rotary valve which fills the space beneath the top cover of the drum just as the crank pin disc occupies the corresponding position above the bottom cover. This valve, which is provided with the necessary passages and openings, is driven by the crank pin prolonged so as to fit into a socket in its face. The steam passes from the central chamber through the valve along passages cast on the sides of the cylinders. Nothing can exceed the compactness and simplicity of the whole arrangement.

Average effort during a revolution in Paragon engine.

It will be seen that the three axes of the cylinders divide the circle described by the crank pin into six equal parts. Now bearing in mind that the steam only presses the pistons outwards, and that some one or other of the pistons is always balanced by back pressure, and consequently in a neutral state, it will be seen that in every alternate division of the circle the two remaining pistons are at work pulling

the crank round, while in the three other divisions there is only one in action. Consequently the average pressure throughout the revolution is that due to a cylinder and a half. Moreover in the three divisions in which single pistons are at work they are in their best position for pulling, while in the other three divisions the two pistons are in their worst position, consequently a great uniformity of effort is the result.

How to work Paragon engine expansively.

It is also possible to work this machine expansively, for by cutting off the back steam at any portion of the stroke it will expand, not balancing the outward pressure entirely, so that the other two pistons will have to pull the third one round against a varying resistance measured by the difference between the outward pressure of the full steam and the inward pressure of the back steam, which latter becomes less and less towards the end of the stroke while the former remains uniform.

High piston speed in Paragon engine.

Another very important advantage of this system is the absence of heavy reversible parts, and the uniformity in the direction of the strains in the connecting rods. This latter point will be clear from the following considerations;—during each outward stroke in any one of the cylinders the piston is pulling the crank, and the connecting rod consequently is in a state of tension; during the inward stroke, on the contrary, the crank has to pull the piston, and the connecting rod then also is in tension, so that no matter how badly the brasses fit on the crank pin there will be no evil effects from back-lash, for the direction of the strain will never be reversed as is the case in ordinary double-acting engines. On account of this peculiarity very high speeds of piston can be attained with perfect impunity. No less than 2,000 revolutions, corresponding to 1,333 ft. per minute, have on occasions been registered.

It is perhaps needless to remark that this type of engine requires next to no foundation.

From Messrs. Brotherhood and Hardingham's list we see that they have already applied their invention to the driving of centrifugal pumps, fans, circular saws, steam launches, capstans, &c., and they certainly deserve and will no doubt obtain every success.

British steam pumps.

The British section was very rich in its collection of steam pumps. Three makers in particular deserve special mention, viz., Messrs. Hayward Tyler & Co., Messrs. Tangye, Holman, & Co., and Messrs. Brotherhood and Hardingham. The two first-mentioned firms exhibited pumps of the direct double-acting type, having neither

crank axles nor fly wheels, the pump cylinder axis being in the continuation of that of the steam cylinder, the pump piston is, in fact, attached direct to the engine piston rod, and the pump and engine cylinders are connected together by a cast-iron frame, much in the same manner as are the plummer block and cylinder of a Corliss engine.

"Universal" pump.

Messrs. Hayward Tyler & Co.'s "Universal" pump was in the opinion of this section of the Jury by far the best specimen of the type in the Exhibition. It is admirable for the excessive simplicity of its mechanical arrangements. The only moving part exposed to view is some two or three inches of the piston rod. Valves and valve gear are all internal and of the simplest sort. At first sight it seems to be a mystery how the machine works, for not only is there no gearing of any sort visible, but also there seems to be no place in which to stow it away, supposing it to exist. It is only on inspecting the drawings that it is discovered that the piston itself besides fulfilling its own proper function, serves also as a steam chest, containing the valve for the distribution of the steam, and also the means for making it self-acting. In order to do all this the piston is necessarily made very long, it is in fact more than half the length of the steam cylinder, which latter is consequently more than double the stroke.

The pump valves are balls made of a composition of gutta percha of about the same specific gravity as water. The seatings are of gun metal, and have never to be replaced on account of the softness of the balls, while these latter when worn out can be renewed with the greatest ease.

The "Universal" pump, as used in mines.

When applied to mining purposes, pumps of this nature may be situated at the bottom of the shaft while the steam generator is on the surface, a point of the greatest importance. All the moving parts being unexposed the machine is little liable to get out of order, and will work well even after months of exposure and neglect. The piston valve is so arranged that the engine will start work at any part of the stroke by the simple act of turning on steam. This latter quality is a great advantage, for it sometimes happens that through an accident, the engine, and consequently the starting gear, are inaccessible, and when this is the case the pumping has to be suspended. With the "Universal" pump, however, this need never happen. There is an instance on record in which a mine provided with one of them was completely drowned. There being no second pump available all operations had to be suspended for some time,

till the attendant, remembering this quality of his engine, conceived the happy idea of getting up steam in his boiler on the surface, and of letting the steam have free admission to the felted pipes which led to the drowned pump below. The experiment answered admirably, for the engine started work of its own accord, and succeeded in pumping both itself and the mine dry.

The "Special" pump. The "Special" pump of Messrs. Tangye and Holman is now one of the best known pumps in the world, and is becoming more and more so every day, so that it is perhaps unnecessary to say much about it here. It is also of American origin, the inventors' names being Messrs. Cope and Maxwell, of Ohio. Its general design is similar to the preceding one. The means for accomplishing the special objects in view are, however, somewhat different, for instance, the valve gear is not contained in the cylinder, but in a separate chest, cast on the outside of the cylinder, and is actuated by the piston, which, at each end of its stroke, knocks against small piston valves in the cylinder covers, and these distribute the steam to a second auxiliary cylinder contained in the chest and provided with a plug piston which carries the valve.

In many new mines these direct double-acting pumps seem to be supplanting the old Cornish system. As an instance of what Messrs. Tangye and Holman have done we may mention the pumping machinery which they have provided for Stannier's collieries in Staffordshire, the principal data of which are as follows;—

Diameter of steam cylinder -	- 32 inches.
„ „ double-acting pump	- 10½ „
Stroke - - - -	- 6 feet.
Depth of engine below surface	- 540 „
Delivery per minute, all in one lift	- *375 gallons.*

But even this performance has since been considerably surpassed.

"Helical" pump. Messrs. Brotherhood and Hardingham exhibited the patent "Helical" pump of Messrs. Bolton and Imray. It was driven at the Exhibition by the three-cylindered "Paragon" engine. The two together were models of compactness and efficiency.

The water is introduced tangentially into a cast-iron casing of rectangular section which winds spirally round the inside of a cylinder in such a manner that the discharge also takes place in a direction tangential to the cylinder. The discharge orifice is exactly over the suction orifice, and the

discharge and suction pipes are in precisely one and the same straight line, so that the water makes one complete revolution in the casing round the cylinder, rises from the level of the one orifice to that of the other, and is then delivered in an unchanged direction.

The section of the spiral casing is large enough to allow a wheel with 12 square blades attached to its rim to rotate within it and to impart the required velocity to the water. The blades which are 12 in number are set radially, and have precisely the same area as the orifices for suction and discharge. The casing is cast in two parts the lower one of which (assuming the plane of the wheel to be horizontal) contains the mouth of the suction pipe, the lower half of the spiral passage, and the bearing for the foot of the axle of the wheel. The upper part contains the mouth of the discharge pipe and the remainder of the passage. The two parts are cast with flanged rims in a horizontal plane, by means of which they are bolted together. The extreme top is occupied by a strong cast-iron cover, which contains a deep bearing for the axle of the wheel, and forms also the bed plate, to which is bolted the three-cylindered engine.

Advantages of "Helical" pump.

This combined engine and pump is becoming very much used for circulating the water in surface condensers. Its makers claim special advantages for it when applied to lifting purposes, as the speed of rotation necessary in order to attain a given height is considerably less than with the ordinary centrifugal pumps.

Other British exhibitors of pumps.

The other British exhibitors of pumping machinery were Messrs. Wilson & Co., whose donkey pumps are well known everywhere, Mr. McNicol of Glasgow, who exhibited one of Clarkson's "Excelsior" pumps, which is a modification of the "Special," and the two firms of Gwynne, whose names are well known in connexion with all sorts of hydraulic machinery. There were moreover two or three other houses.

British steam boilers.

If the British stationary engines were not in every case all that they should have been it is at any rate satisfactory to record that our collection of steam boilers was without parallel in the whole Exhibition. In order to supply steam to the British machinery in motion, Messrs. Galloway supplied to Her Majesty's Commissioners two of their well known boilers, with double furnaces and elliptical flues stayed with the Galloway conic tubes. It is perfectly unnecessary to say more about these boilers, as their excellence is fully recognised everywhere, and was rewarded by the jury with the Grand Diploma of Honour.

Galloway's boilers.

In the British Boiler House two of Messrs. Adamson & Co.'s admirable boilers were fixed, of exactly the same dimensions as those first mentioned. These had each two furnaces, prolonged as separate flues and provided with Galloway tubes, all the butt joints being flanged and the longitudinal seams welded. One of these boilers was steel and the other of wrought iron. Mr. Adamson further exhibited a length of one of the internal flues, which was one of the finest pieces of workmanship to be seen in the exhibition. It consisted of a welded steel cylinder with flanged ends and three Galloway tubes, the whole being forged into one piece without a rivet anywhere. Adamson's boilers.

Next came one of Howard's water tube boilers. Messrs. Howard were also exhibitors at the Paris Exhibition, but their system has been considerably modified since then. The example at Vienna consisted of 20 welded tubes, each nine inches diameter and 20 feet long, set at a slope up from front to rear and connected with one another in vertical rows by transverse tubes in the rear, which in their turn are in direct communication with a cylindric steam reservoir. The flame is guided along the tubes by means of a system of baffle plates. The two top rows act partly as driers, for they are both to a great extent filled with steam, which is exposed to the direct action of the gases and flames from the furnace. If it were not for this arrangement these boilers would probably be bad primers, for the steam as it forms has no direct passage to the reservoir; as it is they are fast becoming very popular on account of their compactness, large heating surface, and rapid generation of steam. Howard's boiler.

The last of the English boilers was manufactured by Messrs. Cater and Walker of Southwark. It is a tubular boiler with external furnace. Several of this type have been in use for some time past in the Albert Hall where they have given great satisfaction. Cater and Walker's boiler.

Three "Economisers," on the patents of Messrs. Green, Messrs. Twybill, and Mr. Bell (all of Manchester), were exhibited in the British department. In their method of action they are all precisely the same, the feed water being forced through a series of metal pipes among which the waste gases circulate on their way to the chimney. Self-acting scrapers are also provided, which travel up and down the outsides of the tubes, removing the soot from their surfaces, and so maintaining their action unimpaired. It is quite possible by means of one of these apparatus to heat the feed water to the boiling point before it is delivered into the boiler. In the case of impure water Economisers.

it would be easy by a slight change in the design of the economiser to deposit all or the greater portion of the impurities before allowing the water to enter the boiler in a separate chamber, whence it could be withdrawn at regular intervals. This would be a great advantage, and the apparatus would often in this manner effect even greater economies than by the simple process of boiling the feed water.

Portable engines.

In the whole Exhibition there were about 63 portable engines exhibited, of which 40 were classed as British manufacture, and the elegance of proportion of these engines, their beauty of workmanship, and, above all, the scientific study and careful experience which had been brought to bear upon their manufacture, culminated in this Exhibition, and showed that Great Britain was far ahead of all other countries in this special branch of her manufactures.

The principal exhibitors of portable engines examined by the Jury of Group XIII. were Messrs. Clayton and Shuttleworth, Ransomes, Sims, and Head, Ruston and Proctor, Marshall, Sons, and Co., Robey and Co., Garrett and Sons, the Reading Iron Works, and Hornsby and Sons.

Messrs. Clayton and Shuttleworth.

Messrs. Clayton and Shuttleworth exhibited the largest assortment of engines, and these ranged from an imposing specimen of the double-cylinder engine of 20 h. p. down to one of 4 h. p. The workmanship of these engines was unimpeachable. This firm has a great reputation in the East, and has turned out, since its establishment in 1848, about 12,500 engines.

Messrs. Ruston, Proctor, & Co.

Messrs. Ruston, Proctor, & Co. exhibited two good specimens of their manufacture, and one of their engines was fitted with their patent expansion stay for connecting the cylinder with the crank shaft saddles. This stay was hollow and filled with steam from the boiler, consequently expanding in the same ratio as the boiler plates.

Messrs. Marshall, Sons, & Co.

Messrs. Marshall, Sons, & Co. were the only exhibitors of a semi-fixed engine and multi-tubular boiler mounted on pedestals in the British department; it was fitted with reversing gear, and is specially suitable for mining purposes. A large double-cylinder engine of about 18 h. p. was also conspicuous in the stand of this firm, in which the guide bars and plummer blocks were compensated so as to alter their position slightly according to the expansion of the boiler; this arrangement showed the refinement to which this class of machinery has been brought, but it is doubtful if it be not too delicate to act satisfactorily in the rough usage to which these engines are usually exposed.

Messrs. Robey & Co. showed several engines manufactured with the greatest care. Their chief novelty consisted in a horizontal governor fitted to the crank shaft of the engine, which acted direct upon the slide valve by means of a carn instead of by a throttle valve. All engineers are now endeavouring to make the governor act directly upon the slide, and although Messrs. Robey's arrangements may be open to some improvements, it is a step in the right direction. Messrs. Robey & Co.

The Reading Iron Works showed one of their portable engines, similar to that which was exhibited at the Cardiff show of the Royal Agricultural Society of 1872, and which gained there so much celebrity. The Reading Iron Works Company.

The fact that the coal used by this engine does not amount to more than 2·35 lbs. per indicated horse-power per hour shows to what a state of perfection high-pressure engines can be brought to at the present day.

The following are the principal dimensions of this engine:

Diameter of cylinder - -	8½ inches
„ stroke - -	14 „
Heating surface fire-box -	40·5 square feet
„ „ tubes -	167·5 „
Total - -	208 „
Area of fire-grate - -	2·37 square feet
Number of tubes -	39
Outside diameter of tubes -	2¾

The following results of the performance are of very great interest:—

Mean dyametrical h. p. -	16·84
Mean indicated h. p. - -	20·53
Mean piston speed - -	322·9 ft. per minute
Steam pressure in boiler -	80 lbs. per square inch
Total coal consumed - -	238 lbs.
Coal used per indicated h. p. per. hour - - -	2·35 lbs.
Water used per indicated h. p. per hour - -	23·75 lbs.
Water evaporated per. lb. of coal - - -	10·1 lbs.
Time occupied in trial till the engine had consumed all her coals and run down	4 hrs. 55¼ minutes.
Mechanical time run, or total number of revolutions during trial divided by nominal speed -	4 hrs. 51⅗ minutes.

The general data of the engine have been given above, it remains only to describe a few of its details.

The cylinder is of course jacketed all over and is not connected with the saddles otherwise than through the metal of the boiler. The valves consist of short slides with an expansion valve working on the back of it. This expansion valve is in two halves which by means of a right and left-handed screw on the valve spindle can be withdrawn from or approached to each other, thus varying the point of cut-off. The spindle is under the control of the governor. In case the engine continues to run too fast even after the admission of steam to the cylinder has been reduced to the lowest limits by means of the valve gear, the governor has also the power of partly closing the throttle valve so as to check the admission of steam to the valve chest. It must be noticed that this was the only portable engine in the exhibition in which the rate of expansion was regulated automatically by the governor.

Messrs. Ransome, Sims, and Head.

Messrs. Ransomes, Sims, and Head exhibited five engines, all most carefully selected, which may be divided into three distinct classes; viz.,—

Class I.—Ordinary portable engines used for thrashing, sawing, hoisting, and other purposes when economy in the use of fuel is not the primary object.

Class II.—Expansion engines in which every improvement has been introduced for economising fuel in an engine occupying a small amount of space.

This class is specially adapted for driving mills and factories, and for motive power in countries where fuel is scarce.

Class III.—Engines for burning vegetable substances such as straw, reeds, maize and cotton stalks, and such like fuel.

Class I. is naturally enough of not so much interest to us from the scientific point of view as are the two other classes, we shall therefore proceed at once to the description of the 12. h. p. engine, belonging to Class II.

12 h.p. expansion engine of Ransome.

The following are the principal data:—

Diameter of cylinders, each	8¼ inches.
Length of stroke	12 „
Revolutions per minute	140.
Heating surface of firebox	32 square feet.
„ „ tubes	180 „
Total heating surface	212 „
Pressure of steam	80 to 90 lbs.

It will be seen from the above figures that the boiler has ample heating surface, from which we should be led to expect a very high evaporative efficiency.

The cylinders are steam jacketed, the jacket being cast in a separate piece into which the cylinder is tightly fitted. The covers are also made hollow so as to contain steam or heated air, which is a very important point to be attended to when it is considered how large a proportion of the total skin of the cylinder is occupied by the covers. The slides are double, that is to say, there are separate expansion valves, and are worked by eccentrics, the outer one of which is loose on the crank shaft and adjustable by means of a quadrant to cut off steam from $\frac{6}{8}$ to $\frac{1}{8}$ of the stroke.

The cylinders are connected with the saddles which carry the crank shaft by means of two bar stays. The latter are put on when the boiler is hot so as to be in their normal condition when the engine is running, but when the boiler is cool and the engine stopped work these stays are of course put in slight compression by the shrinkage of the barrel of the boiler due to its diminished temperature. As the stays are only wanted when the engine is running, this seems to be a very simple and rational arrangement, and far more preferable and cheaper than the ingenious complications which some makers contrive in order to accomplish the same object. This plan has moreover the sanction of successful experience.

All the parts and little details of these engines display the wisest foresight on the part of their designer, for it must be remembered that in most cases they find their way into the hands of owner and attendants who have no technical experience. This consideration has influenced the shape of every part. For example:—the piston rod is screwed into the cross head and held fast in its place by means of a pin, an arrangement which is far preferable to a cottar, as it enables the piston rod to be lengthened by the most ignorant labourer whenever the brasses of the connecting rod wear.

The plummer blocks of the saddles are bored out and the main brasses which are circular on the outside are fitted in, so that fresh ones can easily be put in place without the trouble of fitting them to their seatings. Every surface which may require refitting is formed of such a shape as to be little exposed to the danger of round instead of flat filing.

The arrangement for supplying the boiler with water at a temperature of 210° Fahrenheit is as follows: the pump casing contains two separate pumps worked from one eccentric, the cold water pump draws the water from the tank, and discharges it into a copper reservoir situated in the upper part of the smoke box and in immediate contact with the heated gases and a portion of the exhaust steam. The water which is heated almost to boiling point in this reservoir

flows into the second pump, which forces it into the boiler; and when the engine is working regularly the exact amount of cold water is pumped into the reservoir to be converted into hot water for feeding the boiler.

The engine exhibited at Vienna was of the nominal power of 12-horse, but it was sufficiently strong in all its parts to indicate three times its nominal power, with a consumption of fuel of 3·75 to 4 lbs. of average good coal per indicated horse power per hour. The engine was fitted with a brake to the hind wheels, which consisted of a circular casting bolted to the rim of the wheel, upon which acts a steel band connected with a screw fixed at the back of the fire box. Hitherto the brake has usually acted upon the tire of the wheels or upon the nave, in which former case it was very apt to slip on muddy and greasy roads, and in the latter the whole strain being transmitted through the spokes they were liable to become loose. Messrs. Ransomes' brake, however, does not affect the spokes from being attached to the rim of the wheel, and being completely independent of the tire is not likely to be affected by dirt or grease.

These engines are largely used in all countries where fuel is scarce, and for moderate powers up to, say, 20 or 25 horse power they are rapidly taking the place of horizontal engines with boilers fixed in masonry.

Automatic expansion.

A great improvement has been applied by Messrs. Ransomes, Sims, and Head to their expansion engines, which consists of an arrangement attached to the governor, by which the steam is cut off in the cylinder, in proportion to the load upon the engine, which produces a great economy in fuel, and a much more regular action than the old system of the throttle valve. The arrangement consists of two eccentrics connected with a quadrant or link attached to the cut-off valve working on the outside of the main slide. The pin of this link is attached to a lever connected with the governor by means of a weigh shaft and fork lever. When the engine requires more steam the governor naturally falls and depresses the lever and the quadrant, which alters the lead of the slide, and consequently admits a larger amount of steam into the cylinder. When the load is taken off the engine and it commences to run too fast, the governor lifts the quadrant which causes the valve to travel over a larger space, and admit less steam into the cylinder. This arrangement entirely obviates the wire drawing influence of the throttle valve. It is extremely advantageous for sawing machinery, corn mills, and other machinery where the work is very varied. The special form which the apparatus takes in these engines is the invention of Mr. Brown.

The annexed sheet of indicator diagrams taken from one of these engines of eight-horse power nominal, will serve to show how accurately the amount of steam admitted into the cylinder is proportioned to the duty performed by the engine.

CLASS III. This class of engine is intended to supply a want which has long been felt in those districts where water power does not exist, and where coal and wood are not to be obtained except at an enormous price. Straw burning portable engine of Ransome.

In many parts of South Russia and Hungary the farmer grows a large acreage of wheat and other cereals, and after having used a considerable portion of his straw for fodder and manure, a great quantity still remains, which is perfectly useless, and which has hitherto been burned or allowed to rot in the fields.

It occurred to Mr. Head and Mr. Schemioth, a Russian engineer, that a portable engine might be constructed which would burn straw as satisfactorily as either wood or coal, and after a series of elaborate experiments, they perfected an engine, a specimen of which was exhibited at Vienna. It is well known that if straw and other vegetable substances are laid in a heap and mixed together, they will not burn on account of the insufficient ingress of atmospheric air, and the reason why almost all attempts to burn straw in portable engines have hitherto failed has been because it has always been tried to feed the fire with this fuel in the same way as when coal or wood is used. In the present invention the straw is forced into the lower part of the fire box, about 6 inches above the fire bars, by means of toothed rollers, and is held in suspension in the fire, until each piece is consumed. By this means a large amount of atmospheric air is allowed to penetrate around the straw to be burned, and the bars are placed sufficiently wide apart to allow a free circulation of air, even when they are covered with half burned straw and ashes. The bars are kept free from silica or any deposit by means of a self-acting rake, which can be worked by the stoker, and cuts off the deposit between the bars, and is used during the day, as required.

The ash pan is enclosed at one end, and in order to prevent any danger from fire the ashes are kept moist by jets of water from the feed pump. The heating surface in the boiler is larger than in an engine of the same power in which wood is used for fuel, and the fire box is deeper and longer. The tubes are also smaller in diameter, in order to enable

the whole of the products to be consumed before reaching the smoke box.

A great many experiments have been made with these engines not only in England but also in Austria, and many of them are satisfactorily at work burning straw for driving thrashing machines. They have also been tried for burning cotton stalks in Egypt and indigo stalks in India with the most perfect success.

The results of several scientific trials have proved that it requires about 3·5 lbs. to 3·75 lbs. of straw to do the same duty as 1 lb. of ordinary coal, and about 7 to 8 sheaves of straw are required to thrash 100 sheaves of wheat of the same size.

The engine exhibited at Vienna was of 10 horse-power nominal and calculated to work up to double.

The following are the principal dimensions :—

Diameter of cylinder - - -	9 inches
Length of stroke - - -	12 „
Revolutions per minute - -	140 „
Heating surface of fire-box - -	40 square feet.
„ „ tubes - -	170 „
Total heating surface - -	210 „

All the engines of Messrs. Ransomes, Sims, and Head were remarkable for the beauty of their workmanship and for the elegance and symmetry of their proportions.

Steam fire engines.

The manufacture of steam fire engines has always been a specialty of Great Britain, and it was a pleasure to observe that at Vienna we fully maintained our superiority in this respect. Messrs. Shand and Mason, and Messrs Merryweather have ever been the foremost manufacturers in the world, but they never stand still, and the engines which each of them exhibited at Vienna contain many important improvements over their previous practice. The one sent in by Messrs. Merryweather in particular was the finest example that we have yet seen.

Cranes.

There were several very superior balance travelling cranes exhibited in the British department, Messrs. Appleby Brothers, and Aveling and Porter, having in particular exhibited some which proved invaluable in getting goods into place and taking them away again at the opening and close of the Exhibition. The little machine of Messrs. Aveling and Porter, which was a road locomotive combined with a crane, was especially useful in supplementing the larger and more powerful cranes of Messrs. Appleby for being independent of the rails, no part of the grounds was inaccessible to it. Both these machines are well known and need not therefore be described here in detail. Messrs. Powis & Co., of Milwall, and Wilson & Co., of Liverpool, had each also a very useful

travelling crane, but the most original hoisting machine in the Exhibition was sent in by Brown, Brothers & Co., of Edinburgh. This apparatus was contrived in order to effect lifts in circumstances where great speed is necessary. It has in consequence enormously long steam cylinders and the weight is connected with the power by a system of pulley blocks which act inversely to the usual arrangement, that is to say, the weight moves through a greater space and with proportionately greater speed than the power. Crane by Brown, Brothers & Co.

The crane as exhibited at Vienna had two vertical steam cylinders each over 16 inches in diameter and nearly seven feet long. Between these two is a water cylinder of the same length but lesser diameter. The upper ends of the piston rods of all three cylinders are joined together by a cross head to which is attached the lifting chain and the system of pulleys. The water cylinder serves merely as a brake, and in case of a break down it prevents the pistons of the steam cylinders from knocking against the covers.

This system of hoisting was designed expressly for the rapid loading and unloading of ships.

The hydraulic motors and blowing machinery in the British section do not merit any special notice, we can, therefore, proceed direct to Hydraulic motors and machinery.

France.

France, though admirably represented in the Industry Palace and the Fine Art Gallery had not nearly such an interesting collection of machinery as might have been expected from her, and in this special section of the group she was particularly deficient. It is to be supposed that the war, which was but just over when the preparations for the Exhibition began, must have had some temporary effect in disarranging her more serious industries, for in normal times France is in no respect behind any nation of the world.

Her steam engine manufacturers were represented by the famous houses of Schneider, of Creuzot, and by Fives Lille, the former of which contributed a very handsomely got-up inverted compound vertical engine. French stationary engines.

Messrs. Quillacq, of Anzin, exhibited a large double-cylindered horizontal winding engine, which rather too easily obtained the Grand Diploma of Honour. The drum was fixed on the crank shaft, and the brakes could be worked either by hand or steam. It was provided with an elaborate self-acting alarum and apparatus for preventing over-winding, but the whole machine could not be said to be in any sense remarkable. The same firm exhibited some other engines and drawings of machinery for mining purposes. Quillacq's winding engines.

French combined engines and boilers.

There were a few rather nicely got-up semi-stationary engines combined with boilers exhibited by Hermann Lachapelle, of Paris, the boilers of which were vertical, and the engines supported by a separate frame. Two Lyons houses also exhibited in the same category, and with these we have exhausted the list of French engines.

Belgium.

Belgium has long been one of the best developed industrial countries in Europe; it is, therefore, no surprise to find that she has exhibited one of the most beautiful steam engines in the exhibition. We refer to the one sent in by Messrs. Bède and Co., of Verviers. It was one of the many varieties of the Corliss type so often met with in the Machinery Hall, and was of course horizontal, direct acting, and condensing.

Engine by Bède & Co., Verviers.

The following are its principal data and dimensions:—

Diameter of cylinder - -	17·7 inches.
Stroke - - - - -	39·37 „
Range of expansion from zero to	·7 of stroke.
Steam pressure - - -	60 lbs. per square inch.
Piston speed - - - -	295 feet per minute.
Diameter of double-acting air-pump - - -	8·85 inches.
Stroke of ditto - - -	39·37 „

Both cylinders and covers are jacketed, the valve chests being in communication with the jacket. The valves are of the Corliss type and are somewhat peculiar in their arrangement. The two steam valves are placed inside the tops of the hollow cylinder covers in contact with the cylinder end faces, so that the length of the port is simply the thickness of the metal, and the waste of steam due to long passages is reduced to nil. The two exhaust valves, which are semi-cylindrical, are situated partly in the bottom of the cylinder and partly in the covers, the exhaust steam passing through the covers, so as to be nowhere in contact with the cylinder sides.

The steam gains admission to the jacket through a valve on the top of the centre of the cylinder, and from the jacket it passes through passages into the covers. The valves are opened and shut by a modification of the spring and catch gear so common in engines of this type. The expansion is under the direct control of the governor. The arrangement is the patent of Messrs. Bède and Farcot, and is upon the whole one of the most compact and efficient yet introduced.

The governor is supported by a bracket at the side of the centre of the cylinder, it is driven by bevel gear from the crank shaft, and makes exactly the same number of revolutions as the engine.

The exhaust valves are driven by a cam on the governor spindle, and as the length of time during which these valves remain open or shut is always one and the same constant fraction of the stroke this part of the gear is free from all complication. The cam simply revolves inside of a sliding rectangular frame, to which are connected the valve rods. The motion of the cam pushes this frame alternately to the right and left hand side, thus opening and closing the two valves.

The case is different with the two steam valves, whose period of opening and closing depends on the desired rate of expansion; these are also driven by a triangular-shaped cam on the governor spindle revolving within another sliding frame. This part of the apparatus is situated just over the exhaust valve gear just described.

In the present case the frame is not connected directly with the valve rods, but through the intervention of catch pieces. At a given moment depending on the position of the governor balls, the catch gear is liberated and the valve actuated by a powerful spring on the valve rod returns to its original position, thus cutting off the steam very sharply. This quick return motion is brought quietly to a standstill by means of the usual air buffers or "dash pots," which are cast on arms of the bracket which supports the governor.

The whole arrangement seems to work very well, but it would be impossible to describe it in greater detail without the aid of drawings.

The main framing connects the front of the cylinder with the main bearing in the usual Corliss fashion, thus dispensing with the use of a bed plate. In the present instance this frame forms the front of the hollow cylinder cover, which is not a very good plan as it necessitates the removal of so much of the engine whenever it is necessary to get at the piston for repair. The slides which are circular in section are formed in this frame, being in fact bored out in the same way as the cylinder itself.

The air pump is worked by the prolongation of the piston rod.

The workmanship of the whole engine leaves nothing to be desired. It is not by any means the only object of exhibition of Messrs. Bède; on the contrary they show also a large collection of miscellaneous machinery.

Blowing engine by the Société John Cockerill

The Société John Cockerill of Seraing exhibited one of their vertical compound blowing engines, very similar to the one showed by the same firm at the last Paris Exhibition and referred to in the English Official Report. It need not therefore be described at length here.

Belgian boilers.

There were two boilers in the Belgian Section, one sent by the Société Cockerill, of which nothing need be said. The other was a water tube boiler on Belleville's well known patent.

The remainder of the Belgian Exhibition may be passed over without further comment.

SWITZERLAND.

General superiority of Switzerland.

Probably no country exhibiting at Vienna obtained so many of the greatest prizes in proportion to the number of its exhibitors as did Switzerland.

That this little country with every natural disadvantage should have made such enormous strides in all branches of scientific industry is positively alarming to her richer commercial competitors, but the fact can no longer be denied that Switzerland in whatever branch of industry she exerts herself is now one of the foremost nations in Europe or the world. Her light cotton fabrics compete with our own in some of our best markets. Her silks can compete with those of Lyons or Milan. In the manufacture of watches and scientific instruments at the lowest prices nobody seriously disputes her pre-eminence. In the application of water power to the purposes of manufacture she has taught the world some of its most useful lessons (see official report by Mr. Scott Russell on prime movers in the Paris Exhibition, 1867); while lastly in the manufacture of machinery and high-class steam engines the prize list for the Vienna Exhibition will amply testify that she can hold her own.

We have not far to go for the reasons of all this. The very disadvantages of the country have been in her favour, for she has endeavoured to make good the defects of nature by a perfect system of national education, and by a wise code of social laws, so that her artisans have at once that scientific knowledge of their business which doubles the value of a good workman, and are moreover enabled to work for low wages at a profit to themselves.

Sulzer engine.

The engine which drove the machinery in the Swiss section was made and exhibited by Sulzer Brothers of Winterthür. It has already been mentioned as a noteworthy modification of the Corliss system.

Its principal data are as follows:—

Diameter of cylinder - -	17·7 inches.
Stroke - - -	41·37 „
Range of expansion - -	from Zero to ·70
Steam pressure - - -	75 lbs. per square inch.
Piston speed - - -	344 feet per minute.
Diameter of double acting air pump - - - -	7 inches.
Stroke of ditto - - -	41·37 inches.

As in most engines of this class both cylinders and covers are completely jacketed, and in addition are much more carefully lagged than is usually the case. There are four valves for regulating the steam, viz., two for admission on the top, and two for exhaust at the bottom of the cylinder. All four are of the Cornish equilibrium double beat description, and are driven by a gearing patented by Messrs. Sulzer, and peculiar to their engines. Its nature is as follows:—

A long shaft, driven by bevil gearing from the crank axle revolves parallel to the axis of the cylinder. On this rod are fixed two eccentrics for working the steam valves, and two cams for the exhaust. Of the latter nothing need be said as they have simply to keep the valves open for a certain invariable period of time. With the steam valves it is otherwise. These are each raised vertically up from their seatings by means of a bell crank lever actuated in a manner to be described immediately. The valve spindle during its ascent compresses a spiral spring which directly the pressure is withdrawn, closes the valve with great sharpness and rapidity, the concussion between the valve and its seating being prevented by means of the air cushion which in some form or another is peculiar to most engines of the Corliss type.

The bell crank levers which raise the valves are moved about their fulcrum by the action of the eccentric rods. But if this were all, the valves would be held open for a fixed period like the exhaust. In order to proportion the period of admission to the work to be done the eccentric rod is not allowed to press directly on the bell crank lever, but acts through the intervention of a sliding block, which is attached by a rod and lever arm to a second shaft fixed parallel to the cylinder between it and the eccentric shaft. This second shaft is acted on directly by the governor. Now if the governor at the commencement of the stroke begins to revolve above its normal speed, the shaft is turned through an angle and forces the sliding block out of contact with the eccentric rod and bell crank lever. The latter is conse-

quently liberated, and the valve closed instantaneously by the action of its spring. Thus the admission of the steam is directly under the control of the governor, and the rate of expansion is proportioned to the work to be done. Judging from the indicator diagrams nothing can exceed the perfection of the action of this valve gear. It has moreover the advantage of not easily getting out of order, for the wear of the valve surfaces and seatings is imperceptible, even after years of work, a quality which cannot be claimed for the ordinary Corliss gear.

The manner in which the air pump is worked and also the general design of the framing are similar to the Béde engine last described.

Small engines by Messrs. Sulzer.

Messrs. Sulzer also exhibited two smaller engines, they were of the horizontal direct-acting type, with slide valves, on the back of which worked a semi-cylindrical expansion valve under the direct control of the governor. The other exhibitors of stationary engines in this section were Messrs. Escher and Wyss, the famous engineering house of Zurich, Messrs. Socin and Wick of Basle, and Scheller and Berchtold of Zurich, all of whose objects were of interest, but want of space precludes a detailed description.

Combined engine and boiler by Morell.

Mr. B. Morell, of Basle, exhibited a combined engine and boiler with a high and low pressure cylinder cast in one piece and oscillating, not upon trunnions, but upon a transverse cylinder under their common base which is curved so as to receive this cylinder, somewhat after the manner of the Schmidt pumping engines, which will be presently described. Though novel in design and very ingenious in arrangement, still this engine has several doubtful points about it.

Swiss boiler by Sulzer, Brothers.

Messrs. Sulzer Brothers also exhibited the boiler which supplied their engine with steam. It has been already alluded to (see page 125). Great care seems to have been spent upon its design, but, nevertheless, it is by no means an economical generator, when judged by the standard of our own best practice.

Schmidt's steam-pump and hydraulic motor.

Mr. Schmidt, of Zurich, exhibited a very original steam pump, and also an hydraulic motor, which have hitherto met with considerable success. We shall describe the latter first. —It consists of a cylinder oscillating on solid trunnions and connected like an ordinary steam engine with a crank axle. There are, however, no valves whatever. The lower side of the cylinder (which lies horizontally) is curved from front to rear cover so as to form a portion of a cylinder, the axis of which coincides with that of the trunnions. The two admission ports are contained in this curved portion. It works in a similar hollow curved surface containing the

passages for the supply of water to both ends of the cylinder, and also one for the exhaust. During the oscillation each port is presented alternately to one of the supply, and also to the exhaust passage, and thus the reciprocatory motion of the piston is maintained. The trunnions have their bearings in two powerful lever arms, the ends of which can be screwed down, thus maintaining water-tight contacts between the two curved surfaces.

The pump consists simply of two such cylinders placed opposite each other, so as both to work on a common crank axle, furnished with a fly wheel. One cylinder is of course for steam and the other for water, and the curved surfaces of both are kept in contact with the corresponding faces by levers and screws such as those described above.

Swiss turbine.

As might be expected Switzerland had many exhibitors of turbines. Foremost among these stands the house of Rieter and Co., of Winterthür, who show chiefly drawings of turbines which they have erected in different places, notably at Schaffhausen, on the Rhine.

Messrs. Roy and Vevey exhibited several very interesting models of turbines, the tanks were so arranged that the discharge of the water was visible to the exhibitors. Messrs. Escher and Wyss and Socin and Wick were also exhibitors in this category.

The next country we come to is

Germany.

The exhibition of machinery by the newly constituted German Empire was enormous.

The Ehrhardt engine by Dingler of Zweibrücken

There were in all 16 exhibitors of fixed stationary engines, of these but one was really worthy of serious attention. We refer to Mr. Dingler, of Zweibrücken, who was the manufacturer and exhibitor of the Ehrhardt engine which has already been referred to as being, perhaps, the most interesting prime mover in the Exhibition. It was a compound condensing engine of the horizontal direct acting type, with the cranks set at 180 degrees. The two cylinders were cast in one piece, together with the jacket of the high pressure one. The large cylinder was unjacketed. The valves and their gearing were very peculiar.

The valves themselves, two in number, were long conical cocks, set underneath the two ends of the pair of cylinders and caused to revolve by a worm and screw wheel gearing, from the crank shaft. The expansion was under the control of the governor.

The framing was of the Corliss type, that is to say, the front of the pair of cylinders was connected by means of a hollow casting with the two main bearings. As usual the slides for the crossheads are bored out in this casting, which afterwards branches out into two arms, one going to each bearing. Between these arms there is ample space for the connecting rods to work.

The crank is of the double throw description, the web of one crank being prolonged so as to form the web of the other. The structure of this crank shaft was one of the most difficult practical problems in the whole engine. It is now made of the best cast steel forged, and answers perfectly.

There are two small fly wheels, viz., one on the outside of each main bearing.

The condenser is a separate casting unconnected with the engine, and the air pump is worked by an eccentric from the crank shaft.

The governor is placed on the top of the cylinders, which latter are surrounded by a cleaded cylindrical casing, enveloping both them and the valve casings in such a manner as to give the appearance of a single cylindered engine with two piston rods issuing from it, and intersected obliquely by the two revolving conical valves.

The method by which the governor controls the rate of expansion is exceedingly simple and will be readily understood when the structure of the valves is known. Each of these is cast hollow and provided with the requisite openings in its side and internal passages, in order, firstly, to admit the steam from the boiler to the hollow part of the cone; secondly, to allow the steam to pass from the hollow part into the high pressure cylinder; thirdly, to pass the steam out of the high pressure into the low pressure cylinder; and, fourthly, to open the low pressure cylinder to the exhaust: all this happens too while the valves are revolving continuously in one direction.

The passages in the valve for admitting the steam from the boiler to the high pressure cylinder are near the small end of the cone, and over this end is fitted a cap with passages coincident with those in the cone. This cap is capable of revolving on a spindle which is in connexion with the lever arm of the governor. In its normal condition the cut-off is effected by the conic valve revolving within this cap, and putting the passages out of coincidence. If, however, the engine should run faster than its normal speed, the governor causes the cap to turn through a small angle

in the opposite sense to the revolution of the valve, and thus puts the passages out of coincidence sooner than would otherwise be the case, thus effecting a quicker cut-off without in the least affecting the lead.

It will be seen that a valve of this nature is nearly in equilibrium. The inventors claim for it that if carefully made it will always be swimming in a thin film of steam and oil, and will never be in contact with the surface of the casing, and so will never wear out. Specimens of valves which had been in use for more than a year were shown to the jury and these were absolutely as good as new. Moreover, diagrams taken for the occasion showed their working to be quite satisfactory, no repairs having been effected since the opening day.

The structure of the piston was somewhat peculiar. Mr. Ehrhardt finds from experience that all pistons, no matter how careful the packing, will leak to a very considerable extent so soon as the cylinder has worked a little smooth. He consequently resolved to count upon this leakage as not only certain, but to a great extent advantageous, as it enables the piston to float continuously on a film of steam, which is the best possible lubricator, and which consequently prevents the cylinders from being worn out too rapidly. He has therefore provided no packing whatever, but has simply made his pistons very deep and their sides very thin, so that the pressure of the steam tending to force outwards these thin flexible sides causes them to act very much like Brahmah collars.

Data of Ehrhardt's engine.

The following are the principal dimensions and data of his engine:—

Diameter of little cylinder	4·92 inches.
„ big „	9·84 inches.
Stroke	19·68 inches.
Range of expansion	Zero to ·60.
Steam pressure	150 lbs.
Piston speed	377 feet per minute.
Diameter of air pump	4·92 inches.
Stroke	7·08 inches.

Reasons in favour of the Ehrhardt engine.

This engine was rendered doubly interesting by the publication and distribution of a pamphlet written by the designer containing the result of recent experiments on steam engines, and setting forth his reasons for adopting this special form of compound engine with cranks set at 180°, instead of the single cylindered Corliss engine, or a double cylindered engine with the cranks set at right angles. It would be

impossible here to reproduce his whole pamphlet, but its contents may be summed up in a very few words.

He first of all discovered from his experiments that the direct leakage of steam from the boiler through the valves and piston to the condenser is one of the principal losses in an engine, and that this loss is proportional to the difference in pressure between the boiler and the condenser; also, as the force causing the loss is constant, viz., the uniform pressure of the steam, and the force which resists it is also constant, viz., the tightness of the valves and piston, that consequently the loss, if it occurs at all, is constant per unit of time.

Hence he concludes that speed of piston is an element of the first importance, for in an engine of a given size the power developed is directly proportioned to the piston speed, and as the loss due to leakage is proportional to the time passed over it is manifest that the ratio of steam lost to steam used is much less than in the case of a slow-speed engine, for in a given space of time the loss itself is constant, but in the one instance the power developed in the time is much greater than in the other.

But high speed of piston in a single cylindered engine worked economically involves a great initial pressure of steam coupled with a high rate of expansion. Now, all this involves a very costly engine, and one also difficult to keep in repair, for in the first place the proportions of all the parts have to be designed with a view to this high initial pressure let on to the piston just when the crank is at its dead centre, that is to say, at a time when the pressure of the steam, instead of producing motion tends to tear the engine to pieces. Now the work done by the machine is due, not to the initial, but to the mean pressure in the cylinder, hence a single cylindered engine run at a high speed economically must have all its parts unduly strong, and consequently heavy, in proportion to its size and power, and as the heavy moving mass of harmful but necessary material which this involves has to be reversed at every stroke, the fly wheel has to be made proportionately large, thus increasing the friction on the already over-strained main bearings.

Another point of great importance is this, that in an engine of this nature using steam expansively the temperature varies very much in the cylinder during each stroke, on account of the variation of the pressure and the heat converted into mechanical work, and consequently the hot steam from the boiler enters the cylinder when it is chilled down, and in consequence a great portion of it is condensed at the beginning of the stroke and re-evaporated towards the end,

where it can do but little useful work, and so may be said to be wasted.

Now a little consideration will show that all these defects are in a great measure cured by the use of a compound engine with cranks set at 180°.

In the first place the strain on the main bearings when the cranks are at their dead centres is reduced to zero, for the pressure of the high steam in one direction is balanced by the low steam in the contrary direction. Next the mean pressure in each cylinder is much more nearly equal to the initial pressure than in the former case, and hence the strength and weight of the parts does not bear nearly such a disproportion to the power of the engine as before. Consequently the weight of the moving parts can be correspondingly reduced, and as these in their motion balance each other, and as moreover the average effort on the crank is much nearer to uniformity than in the single-cylinder engine, the fly wheel may be reduced accordingly, thus further diminishing the weight on the bearings. Moreover, the necessary weight of fly wheel can in this case be divided over these two bearings, instead of being all concentrated over one, as before. Consequently, as the crank shaft has not such a heavy load to bear, and as the load, such as it is, is better distributed, it also may be reduced in size.

Of course the difference of temperature in each cylinder during the stroke will be considerably diminished, for the whole expansion instead of taking place in one cylinder takes place in two, and the difference of temperature is therefore distributed over both, and the loss due to the condensation of the fresh steam is in a great measure done away with.

As regards leakage it will be seen that the steam from the boiler has in this instance to leak through two pistons and sets of valves, instead of through one, before it gets to the condenser.

Moreover, as this leakage is proportional to the difference of pressure on both sides of the piston it will manifestly be less in this case than in that of the single cylinder, for the difference of pressures, instead of being that between boiler and condenser, is now only due, in the first place, to that between the high pressure on one side of the little piston and the low pressure on the other side, and in the second to that between the low pressure in the large cylinder and the vacuum in the condenser.

It must also not be forgotten that any steam leaking to the wrong side of the small piston is partly used in the large cylinder.

These were the considerations which induced Mr. Ehrhardt to design his engine as he did, and it must fairly be acknowledged that he has made out a good case for himself. The working of the engine was absolutely noiseless, nor was there a thrill or vibration perceptible at any of the bearings, and from this circumstance the freedom of the engine from repairs may be inferred. The efficiency of the peculiar features such as the valves cannot be gainsaid. The lightness of most of the parts is positively astonishing, and in the whole engine we can really only find three details to criticise, and these can easily be remedied in future practice.

Firstly. The jacketing was insufficient, having been applied only to a very limited portion of the small cylinder.

Secondly. The connecting rods as compared with the rest of the moving parts were made absurdly heavy; this was done with the avowed intention of preventing "whipping," but there are better means of accomplishing this end than by making the rods of a heavy solid round section.

And, thirdly. The connexion between the caps on the valves and the lever of the governor seemed clumsily thought out, when judged by the standard of neatness of the rest of the engine.

German steam pumps.

There were several exhibitors of steam pumps in the German section, but of all these we shall only refer now to the Brothers Decker, of Canstatt, in Würtemberg. Their collection comprised a number of pumps of different sizes in the Machinery Hall itself, and also a large pair of pumping engines in the grounds for the service of the fountains.

These latter were of the direct-acting non-rotative type, and were made on Earle's American patent.

The diameter of the steam cylinder was $15\frac{3}{4}$ inches.
The stroke - - - - 37 „
The pump cylinders were exactly the same size.
The steam pressure was 60 lbs. per square inch.

Number of double strokes per minute was 10 at the Exhibition, but as the engine was intended for quite other work under other circumstances the above figures do not go for much.

Each engine was quite detached from the other as far as their parts went; the connexion was a common air vessel placed between them.

The cylinders were connected with the pumps in the usual way. The valves were worked by means of an arm on the piston rod which, in either stroke, came into collision

with buffers on the valve spindle, and put the valve into such a position as to close both ports, the used steam completing the travel.

The steam was condensed by being passed into the suction pipe by an arrangement patented by the Brothers Decker, which seems very efficient.

The air vessel is a large wrought-iron cylinder, divided into two compartments by means of a diaphragm.

The part below the diaphragm is for the suction, while the part above is for the delivery pipe. It is fitted with an ingenious apparatus for replenishing the lost air.

For several weeks after the engine was first set to work it shook very badly at each stroke; this was probably due to the pump valves, which do not seem nearly so well arranged as in the English engines, that for the suction, for instance, consisted of a solitary disc of leather of large diameter stiffened with wrought-iron plates closing the head of each branch.

German boilers.

The German boiler house was very remarkable for the number of steam generators which it contained of an unusual type.

Meyn's boiler.

The most peculiar, perhaps, was the Meyn patent boiler exhibited by the Carlshütte of Rendsberg and largely patronised at Krupp's works at Essen. The exterior is a simple cylinder set vertically, but within, it consists of a most intricate combination of direct-acting surface, water-tube, and fire-tube, which would defy accurate description without the aid of drawings to refer to. These boilers may perhaps be good steam generators owing to the great extent of heating surface, but that they are easy to keep in repair seems more than doubtful, owing to the great number of joints, and the inaccessibility of the various parts. The water tubes are not circular in section as might be expected, but are egg-shaped, with the small ends pointing inwards in order that the greatest possible number may be packed round the circle. Moreover their sides are corrugated, partly in order to strengthen them and partly to increase the heating surface.

Pauksch and Freund's boilers.

There were two tubular boilers exhibited by Messrs. Pauksch and Freund of Berlin, the peculiarities of which were the tubes and the manner of fastening them in place. They were made of drawn wrought iron and were fixed by means of the tools patented for the purpose by a Frenchman named Berendorf. The most opposite accounts of this system of tube fastening obtain circulation. There seems however to be little doubt that in Pauksch and Freund's boilers it has not met with success.

Bergman's boilers.

Bergman of Hattigen in Westphalia exhibited two specimens of his patent boiler which have met with considerable attention in German scientific journals during the past year. They are each vertical cylindric shells, all the heating surface being external. The cylinder is much wider at the top than at the bottom, the difference in diameters forming a circular rim or shoulder, in which a number of Field tubes are set so as to hang down in the flames which envelope the skin of the lower part of the cylinder. The feed-water is introduced near the extreme bottom or foot of the boiler, which part is not exposed to the direct action of the fire. The mud is deposited below the feed orifice, and can be readily withdrawn as occasion requires, and the water ascends gradually to the hotter parts in such a manner that while the circulation goes on unimpaired the motion of the water is very quiet and uniform, a state of things which tends greatly to diminish the evil of priming.

Dingler's boiler.

Another boiler in this department was devised by Dingler of Zweibrücken, to supply steam at the high pressure of 150 lbs. per square inch, which he prefers to use in the engine exhibited by him. It consisted of two barrels of comparatively small diameter set in a horizontal position one above the other and communicating by means of short wide water legs. The lower barrel is multitubular, the upper one being a plain shell, round which the gases circulate and in which the steam is probably superheated. Somewhat similar steam generators have already been used in this country and in France.

Hydraulic motors.

The German collection of hydraulic motors was more complete and imposing as well as more interesting than that of any other country represented in the Exhibition.

The principal exhibitors were Messrs. Straub of Geislingen, and Messrs. Nagel and Kaemp of Hamburg, and the Augsbourg Maschinen Fabrik. There is most to be learnt from the Nagel and Kaemp collection; we shall therefore describe it alone in detail.

Turbines by Messrs. Nagel and Kaemp.

Amongst other objects there were four turbines exhibited by this firm, nearly all of which present interesting features.

The first had a vertical axis, the wheel being 36½ inches external diameter, with full delivery of water, and destined for low falls. The water was admitted from *below* into a central guide wheel, so that the foot of the pin was relieved from all downward pressure, a point of the greatest practical importance.

The way in which the supply of water is regulated and the buckets altered to suit the varying supply, is the chief peculiarity of this turbine. The top of the guide wheel is

closed by a cast-iron disc, which can be moved up and down together with the guide wheel, so as to present a larger or smaller section for the issue of the water to the bucket wheel. If the space between the buckets remained constant to this varying supply the useful effect of the turbine would be diminished as the supply became less, for it is to be supposed that the buckets were originally designed with a view to the normal delivery. In order to obviate this disadvantage, the space between each bucket is completely filled by a plate lying in a horizontal plane, which can be shifted up and down, so that the space in question is divided into two parts by a horizontal partition, the position of which can be altered at will. All these plates are combined into one system by means of a cylindric cast-iron casing which envelopes the outside of the bucket wheel and to which the outer edges of the plates are attached, while their inner edges are in like manner fastened to a ring.

Now the whole point of this apparatus and the accompanying mechanism is this,—that these horizontal partitions and also the plate which closes in the top of the guide wheel shall always be simultaneously in the same plane. In this manner the depth of the guide wheel and the depth of the buckets, though constantly varying, will always be the same with regard to each other, an arrangement which is theoretically perfect.

The second is a partial turbine, likewise with a vertical axis, and nearly seven feet in diameter. In this case also the water enters from below and passes into a drum-shaped chamber in the centre of the wheel, the space round which is occupied by a ring-shaped guide wheel, and outside this again is the bucket wheel. This central chamber is of course roofed over so as to prevent the escape of the water upwards. It is further provided with two delivery passages for the water, which are exactly opposite to each other; the reason for this arrangement being, that all lateral stress on the turbine axis may be avoided.

The guide wheel can be moved round by means of mechanism provided for that purpose, and the guides are so arranged that in one position of the wheel none of them are opposite to the delivery ports, while by turning the wheel round, a greater or fewer number of them can be presented, and thus the power of the turbine is regulated.

The third turbine exhibited by this firm was likewise a partial one, was 1 ft. 9½ inches in diameter, and was mounted on a horizontal axis. It was remarkable chiefly for its self-

acting regulator. The arrangement for the delivery of the water to the buckets being similar to that last described.

The bucket wheel was surrounded by another wheel on the same axis provided with perfectly radial blades, and connected by gearing with the guide wheel in such a manner that if the wheel with the radial blades be turned through a small angle to the right or left, a greater or fewer number of guides are presented before the water delivery port, and thus the power developed by the wheel is regulated.

The manner in which the movement is effected is exceedingly simple and ingenious. In a Fourneyron turbine working with maximum effect the water should on leaving the wheel assume a perfectly radial direction, and when this is the case the issuing streams pass between the radial blades of the regulating wheel without causing any motion of this latter.

But should the turbine not be developing its maximum effect in proportion to its water supply, *i.e.*, be running too fast or too slow, the water will not issue radially but at an angle on one or the other side of the radial line, and will consequently not pass without effect between the blades, but will strike them on one face or the other, thus moving the regulating wheel through an angle to the right or left, and consequently turning a greater or lesser number of guide buckets into position before the port.

The fourth and last turbine is 3 ft. 7¼ inches in diameter, and like the last is mounted on a horizontal axis. It does not however present any such interesting features as the other three.

Turbines by the Augsbourg Maschinen Fabrik Co.

Of the other German exhibitors in this category the Augsbourg Maschinen Fabrik Co. had perhaps the most interesting collection, although it consisted only of a large model and several working drawings.

The model is of a turbine on the Henschel Jouval system of 1,200 horse-power for a factory close to St. Petersburg. Its principal data are as follows:—

Diameter of wheel - - -	12 ft. 6 in.
Height of fall - - -	25 ft.
Water used per second -	568 cubic feet.
Revolutions per minute -	50

Remainder of German Exhibition.

The only other objects of any interest in the German department are the Siemens' heat motors referred to above. In addition to these not being as yet practical inventions, they are moreover so unusual both in principle and in the shapes of the separate parts, that it would be futile to describe them without detailed drawings. There were numerous fire-engines exhibited, but there was nothing in any of them

from which Messrs. Shand and Mason or Mr. Merryweather could take a hint. A similar remark applies to the portable engines, while their overhead travelling cranes were probably the most complicated specimens of mechanism in the entire building; we may therefore proceed without further delay to

Austria.

General characteristics of the Austrian department.

Probably few foreign exhibitors were prepared for the extent or perfection of the Austrian Exhibition taken as a whole, but while admitting all this, it must be acknowledged that in the Machinery Hall, though the space occupied was large and the objects exhibited by several firms showed signs of considerable advancement in mere skill of manufacture, still there was little to be seen that could be called original: for the greater mass of objects were simply reproductions of ideas which have already been developed by the more advanced countries.

Austrian steam engines.

Her steam engine production was represented by no less than seventeen exhibitors.

Engines by the Maschinenbau Actien Gesellschaft of Prague.

By far the most imposing collection was that of the Maschinenbau Actiengesellschaft of Prague (formerly Danek and Co.), most of the engines and other machinery of which were exhibited in a separate pavilion alongside the main building. The company exhibited in all five engines, of which one was for winding purposes.

The largest was an enormous pair for a rolling mill, of the horizontal direct-acting type and non-condensing. The cylinders were each $43\frac{1}{2}$ inches in diameter $\times$ $51\frac{1}{5}$ inch stroke. The valves were driven by a link motion. With a working pressure of 75 lbs. per square inch and a normal cut off at $\frac{3}{4}$ of the stroke, this engine is intended to attain a piston speed of 853 ft. per minute. The same firm exhibited also a couple of large horizontal direct-acting engines, one of which is intended for a rolling mill, but neither of them present any features of interest.

A fourth engine was a horizontal direct-acting compound engine in the Machinery Hall itself, with cylinders respectively $10\frac{3}{8}$ and $20\frac{3}{4}$ inches in diameter, the common stroke being 28 inches. The cranks are at 180°, and the arrangement of the valves, though somewhat peculiar, is hardly worth while imitating.

Next in importance to the above come the collections of the "Maschinen und Waggonbau Actiengesellschaft" in Simmering, and of the well-known firm of Sigl in Vienna, Berlin, and Wiener Neustadt. Each of these houses showed three engines.

Engine from the Simmering factory.

One specimen by the first-mentioned firm is remarkable for its valves, which are of the revolving type devised by Professor Radinger of the Vienna Technical High School. The object of this arrangement is similar to that of the Ehrhardt gear already described, but is not nearly so well carried out.

Sigl's engines.

The Sigl engines are all of the horizontal direct-acting type, having a valve gear, somewhat similar to the small Sulzer engines in the Swiss department. The largest of them was employed in driving a portion of the shafting in the Austrian section.

Wannieck's engine

Of the modifications of the Corliss type the only one worthy of special mention was exhibited by Wannieck of Brunn. It was remarkable merely for innovations in the valve gearing.

Austrian steam pumps.

The Austrian steam pumps which deserve special mention were exhibited by the Erste Brunner Maschinen Fabrik Gesellschaft, and were employed in raising the water to the reservoir on the top of the large water tower. They consisted of a pair of Corliss engines coupled on to a common crankshaft on which was keyed a heavy fly-wheel. Either engine could however be worked independently if necessary.

The piston rods were produced beyond the rear cylinder ends and formed also the pump rods, the pumps themselves being contained within castings placed behind the cylinders, in the same manner as condensers are often arranged. A large wrought-iron reservoir placed between the pumps played the part of air vessel to both the suction and delivery pipes, in addition to which there was the usual small air vessel on the top of each of the pump castings.

The exhaust steam was employed to heat the feed water by being passed through an apparatus somewhat resembling a tubular condenser placed between the cylinders below the level of the floor.

The following are the principal data of these pumps:—

Diameter of each cylinder - -	19·75 inches.
Stroke of each cylinder - -	43·55 inches.
Diameter of pump cylinder - -	12 ins. (bare).
Steam pressure - - -	70 lbs. per sq. in.
Height to which water is raised above pump - - - -	155 ft.
Height from which water is sucked -	18·5 ft.
Maximum supply per minute -	62 gallons.

The engine is a very good specimen of Austrian workmanship, and the arrangements, including an automatic telegraph which indicates in the engine-room the height of water in the tank, are remarkably neat and handy.

Of the many stationary steam boilers exhibited by Austria two sets deserve special attention.

Sigl's boilers with Zeh's fuel feed.

The first was manufactured by Sigl and supplied the steam for his engine. It was remarkable for a self-acting fuel feeder invented by Herr Zeh.

The apparatus consists of a large cast-iron hopper to be filled with fuel and attached to the front face of each boiler The bottom of this hopper can be opened or shut at will, being thus put into communication with the interior of the furnace. The automatic part is as follows. The steam pump is made to drive a small shaft extending along the front of the tier of boilers some little distance above the hoppers. A separate eccentric for each shaft is keyed on to this shaft and is put into communication, by means of a rod, with the moveable mouth of the hopper, consequently every time the shaft revolves this mouth opens into the furnace and a little fuel is injected on to the bars. These latter are very steep, so that the fuel travels forward by its own weight alone. The arrangement is said to have found considerable favour with the Viennese steam users.

Considered apart from the fuel feed, these boilers presented no very remarkable features, being merely modifications of the French "Chaudière a bouilleurs," so arranged however that the feed water should constantly travel forward to the hottest part of the heating surface in exactly the opposite direction to the flow of the gases, thus abstracting the maximum of heat from these latter.

Tedesco's boilers with Bolzano's patent grate.

The second set of boilers which deserve attention were manufactured by Tedesco and Co., of Prague, and supplied the steam for the Decker pumping engines. They each consisted of a multitubular cylindric main boiler, surmounted by a second cylindric shell or steam chest, the furnace being underneath the main portion. The chief peculiarity was the fire-grate invented and patented by Bolzano. It is arranged in three independent steps or planes, of which the lowermost is horizontal and the two upper are inclined downwards and inwards in position.

The furnace mouth is closed by a casting, which forms at one and the same time a hopper to contain the charge of fuel, and also a door to close the furnace mouth. It is mounted on pivots, so that to charge the first grate it is only necessary to turn this hopper quickly on its axis, when the fuel which it contains is shot forward on to the bars. The furnace mouth, owing to the shape of the hopper, remains nearly closed the whole time, thus preventing an undue admission of cold air during the process of firing.

The two inclined grates are so arranged that every second bar can be jerked up beyond its normal level by means of a pair of levers whenever it is necessary to shake out the clinker: by these means also the incandescent fuel is gradually worked forward on to the second and third grates and when this last one is covered with cinder it can be drawn bodily forward by means of a draw-bar provided for the purpose, its contents falling into the ashpit. It is claimed for this grate, that it effects a very perfect combustion of the fuel with a limited admission of cold air. It has been tried successfully with the Austrian brown coal.

Of the remainder of this section of the Exhibition it is not necessary to say much. It was certainly great in extent, and proved that Austria is fast advancing along the road of civilisation opened up to her by some of her more advanced neighbours.

Of the other civilised countries represented in the Exhibition, several, viz., Sweden and Norway, Denmark, Russia, Italy, Spain, and Hungary, have not yet been mentioned, for they contained little of exceptional value to report upon.

GEORGE C. V. HOLMES.

Westwood Lodge, Sydenham, S.E.,
14th February 1874.

Colonel MICHAEL.

AGRICULTURAL MACHINERY.

REPORT on AGRICULTURAL MACHINERY (Group XIIIa.) by Lieutenant-Colonel MICHAEL, M.S.C., late Forest Department, and Honorary Secretary to the Government Experimental Farm, Madras, Member of the International Jury at the Paris Exposition of 1867.

Before commencing a notice of the Agricultural Machinery, shown at the Universal Exhibition of Vienna, I desire to preface my observations with the remark that, as they are intended, mainly, for readers who are principally interested in the machines exhibited in the British Section, reference to foreign exhibits will be limited, in a great measure, to those which were considered by the jury particularly worthy of notice, and likely to be interesting or valuable to English agriculturists.

I would, moreover, explain that, owing to the publication, as an appendix to these reports, of a series of Technical Papers on all the more important machines and implements exhibited at Vienna, it would be superfluous, on my part, to do more than generalise upon the exhibits of the whole group, as they have been thus dealt with, individually, by abler professional pens than mine, and any reader desiring to learn technical or mechanical details has the articles in question at hand to refer to.

Starting, therefore, with the Agricultural Machinery exhibited in the British section, it may be interesting to glance at the past history of this important branch of England's exported machinery, and its future in Europe and other quarters of the globe.

Before the Exhibition of 1851, England stood first amongst all nations as regards the scientific development of her agriculture, and the ingenuity and practical application of mechanical science which had been brought to bear upon agricultural machinery. The Royal Agricultural Society of England had taken much pains to encourage improvements in all classes of implements, and their prize awards were regarded by foreigners as guarantees of the highest state of perfection in any particular class of agricultural machinery.

Comparatively few machines, however, were sold out of England to foreign farmers until after the French Agricultural Exhibition in 1856, when a series of smaller exhibitions was organised abroad, which were attended by most of the

principal English manufacturers, and the foundation was then laid for many of the large agencies which serve to distribute the products of the British workshops to the farmers in the most distant parts of Europe.

About this time Messrs. Clayton & Shuttleworth established a small repairing shop at Vienna, which has now developed into a large and important manufactory, in that city, employing more than 500 men, and the firm has branches at Pesth, Prague, Galatz, and Czernowitz, which are supplied with engines and thrashing machines from their workshops at Lincoln, and with smaller implements from Vienna.

The excellent display of agricultural machinery at the London Exhibition of 1862, and the easy access which foreigners obtained to the large farms and manufactories of England, during their stay, further increased their knowledge of British agriculture, and enabled them to appreciate the rapid strides which had been made. Steam tillage had been introduced by the inventions of Messrs. Fowler and Howard, and vast improvements had been made in implements for harvesting the crops, such as reapers, mowers, &c., and in steam thrashers and other machines for preparing the grain for market. The export of British machinery increased considerably after the exhibition of 1862 to all parts of Europe; and Hungary, Wallachia, South Russia, and even Spain benefited largely by the introduction of strong and durable implements.

At the Paris Exposition of 1867 England exhibited largely, and an attempt was made to combine a permanent trial field at Billancourt, with the Exhibition of Agricultural machinery, not in motion, in the "Champs de Mars;" but the idea was a failure, as the experiments were carried out on too small a scale to give any real practical results.* In the awards of prizes the British exhibitors of agricultural machinery were all placed in the foremost rank, and two firms, Messrs. Ransomes & Sims and Messrs. Howard, were both awarded a "Grand Prix," an honour which was reserved but for few Englishmen.

After the Paris Exhibition, a great development took place in the demand for agricultural machinery, and especially that of English manufacture. This was further stimulated by special arrangements which were then made in the corn growing districts of the east for transporting the grain from the interior to the seaboard by railway

* The trials of the Mowers were made at the Emperor's farm at Fouillese, near St. Cloud, and of the Reapers at the Imperial establishment at Vincennes.

instead of bullock wagons, and from the Black Sea and Danube ports, to Marseilles or Falmouth by fast screw steamers instead of by sailing vessels; it followed, therefore, that reaping machines and thrashing machines, of great power, were necessary to enable the farmer to send his produce in good time to market, and I believe it is a fact that, whereas in 1862 the grain grown in the interior of Russia and the Principalities did not arrive at the Western ports until about ten months after the harvest, in 1873 the corn, which was growing in Podolia and Bessarabia in the months of July, was delivered in Falmouth by the end of October.

Before the preliminary arrangements connected with the Vienna Exhibition were made, several British manufacturers of agricultural machines had almost decided not to exhibit on account of the unsatisfactory position which had been allotted to exhibitors in this section at former exhibitions, but on the promise of Baron Schwarz-Senborn to reserve an annexe for the agricultural machinery of Great Britain in the most frequented thoroughfare, *i.e.* between the main building and the "Maschinen-Halle," it was generally determined by the English implement manufacturers to make a good show at Vienna, and it may be said that never before has the world seen such a fine display of agricultural machinery, constructed on the most scientific principles, and of the best materials and workmanship. One of the most satisfactory features, moreover, of the "Agricultur-Halle," was its accessibility to the ordinary visitor. Those who undertook the journey from the Paris Exhibition to the island of Billancourt must remember the dreary and deserted aspect of the sheds, and it was wise on the part of the authorities to assign so prominent a place to the agricultural machinery at Vienna. It is probable that a very small per-centage of the visitors to the Exhibition left the grounds without having passed through some part of the machinery buildings, and consequently a vast number of people who had no definite ideas of agricultural machinery and its great utility, had an opportunity of learning one of the lessons which universal exhibitions are designed to teach.

The British manufacturers obviously made every effort to show the extent of their constructive abilities at Vienna, because that city being situated at the entrance to the greatest corn growing countries of Europe, the exhibition gave them the opportunity of showing the eastern farmer that, although so far distant, they thoroughly understood his wants.

Until within the last few years it had been the custom of the foreign farmer to buy copies of the best English

machines without any regard to their suitability to his soil and climate, but it was soon found that if the English manufacturers were to maintain their trade, they must study modes of agriculture pursued in other countries, differing in many points from the advanced system prevalent in England. This necessitated various changes in the construction of the implements in order to render them more suitable and profitable, and it is for this reason that so many ingenious designs and practical improvements are to be found at the Vienna Exhibition.

It was not till after all the arrangements of the building, for the exhibition of agricultural machinery, had been completed that the Austrian Government organised a series of trials, to take place at two sites, namely, Siebenbrunn and Leopoldsdorf, situated about 10 English miles from Vienna, and the programme was communicated to the various exhibitors in England. A meeting was however held in London in March, attended by almost all the principal firms interested, and it was unanimously resolved not to take part in the trials. The reasons assigned for taking this step were, firstly, that past experience of trials by International juries, had always been unsatisfactory; secondly, because the short time allotted for the duration of the trials could, even with the best organisation, only have admitted of a hasty and insufficient experiment with each machine; and thirdly, because great additional expense must have been entailed on exhibitors in bringing out workmen from England and preparing a double set of machines, or, in lieu thereof, removing their implements from the main building in the Prater for two or three weeks, which would have prevented the public from seeing a complete collection.

It was at one time stated that the Austrian Commission would grant no awards to agricultural machinery not entered for trial, and the British exhibitors were at first considered to be *hors concours*; but on the assembling of the jury in the month of June, the justice of the decision arrived at by the British agricultural implement manufacturers collectively, was at once recognised, and the awards were made after careful examination of the different exhibits, and a minute investigation of any novelty brought out since the Exhibition of 1867.

At the first meeting of the international jury it was determined that Group II. should divide itself into six sections, Section V. being specially charged with the examination and judging of agricultural machinery, which was classed under Group XIIIa.

The section was constituted as follows:—

PRESIDENT.

E. Tisserand. France. Inspector-General of Agriculture. Member of the International Juries of 1862 and 1867.

VICE-PRESIDENT.

P. S. Aureliano. Roumania. Director of the Central School of Agriculture of Roumania; member of the Jury 1867.

SECRETARY.

Paul Teray. Hungary. Landed proprietor. Pesth.

MEMBERS.

A. V. Beck. Denmark. Hofjägermeister to H.M. the King of Denmark.

M. Boutarel. France. Member of the Commissions and of the Juries of 1862 and 1867.

E. B. Eichmann. Austria. Manufacturer of machinery.

W. Kraus. Austria. Council of Agriculture in Prague.

Lieut.-Colonel Michael. England. Late Forest Department, and Hon. Secretary to the Government Experimental Farm, Madras; member of the Jury at Paris 1867.

H. Nathorst. Sweden. Director of the Agricultural College at Olnarp.

Baron Romaszkan. Austria. Landed proprietor. Hawdenka.

N. Solsky. Russia. Director of the Agricultural Museum at St. Petersburgh.

H. Thiel. Germany. Council of Agriculture in Berlin.

Captain I. Campbell Walker. England. Deputy Conservator of Forests, India.

The jury commenced work on the 16th of June by electing their President, Vice-President, and Secretary, and agreeing to meet daily at 9 a.m., went about in a body, till 12, examining the machinery, and assembling again occasionally in the afternoons to compare notes, discuss awards, and record their proceedings. Steady adherence to this plan enabled them to complete their labours in about six weeks, when their protocol was submitted to a meeting of the whole of Group II. who confirmed the awards.

The examination was a most searching one. Every individual machine which showed any merit, and in many instances the detailed construction, was thoroughly inspected; and some idea of the work may be obtained when it is stated

that the exhibitors of all nations displayed upwards of 1,200 of the more important machines used in agriculture, and minor implements without number. The duty was a very laborious one, and performed as it was in the midst of the hottest part of the Austrian summer, it would have been most irksome had it not been for the cordiality and good fellowship which existed among the members of the jury. A few words are necessary to explain the system under which the awards were made on this occasion. The theory of the Austrian administration was that all medals should be of equal value, each merely bearing on it a device showing the reason for which it was awarded, *i.e.* "Progress," "Merit," "Good Taste," or "Co-operation." But this idea could not be carried out in practice, and the section of the jury for agricultural machinery, in common with many other sections, found it impossible to do justice otherwise than by assigning grades to the awards, and therefore a "Diploma of Honour" may be considered a special order of merit. "Progress" being held equal to the gold, and "Merit" to the silver medals of former exhibitions, the medal for "Good Taste" was naturally inapplicable to agricultural machinery, and "Honourable Mention" bears its usual significance. It is important also to state here that exhibitors of each country were judged not as competing with those of other countries, but as competing among themselves only. Thus "Öfverums-bruk," of Sweden, "Polgar," of Hungary, "Collins & Co." of America, and "Mougeot," of Oran, in Algeria, each get the medal of "Merit" for ploughs, but it must not be supposed that the implements were therefore of equal excellence.

The conditions under which the trials of the reaping and mowing machines took place, at Siebenbrunn, were such as to exert little or no influence on the decisions of the jury. The British exhibitors having, as before stated, decided that they would not submit their machines to field trials, their example was followed by most of the exhibitors of other nations, the Americans and a few Austrians being the only so called competitors. The result proved that the English were right, for no trial or competition according to the true meaning of the terms could be held, even for Reapers and Mowers, because, although there were standing crops of rye to be reaped, and vetches, &c. (but no grass) to be mown, the only cattle available to draw the machines were rough, half trained horses of unequal power, many of which had never been in a Reaper before.

TABLE showing the NUMBER of AGRICULTURAL MACHINES and IMPLEMENTS exhibited by the different Countries at VIENNA in 1873.

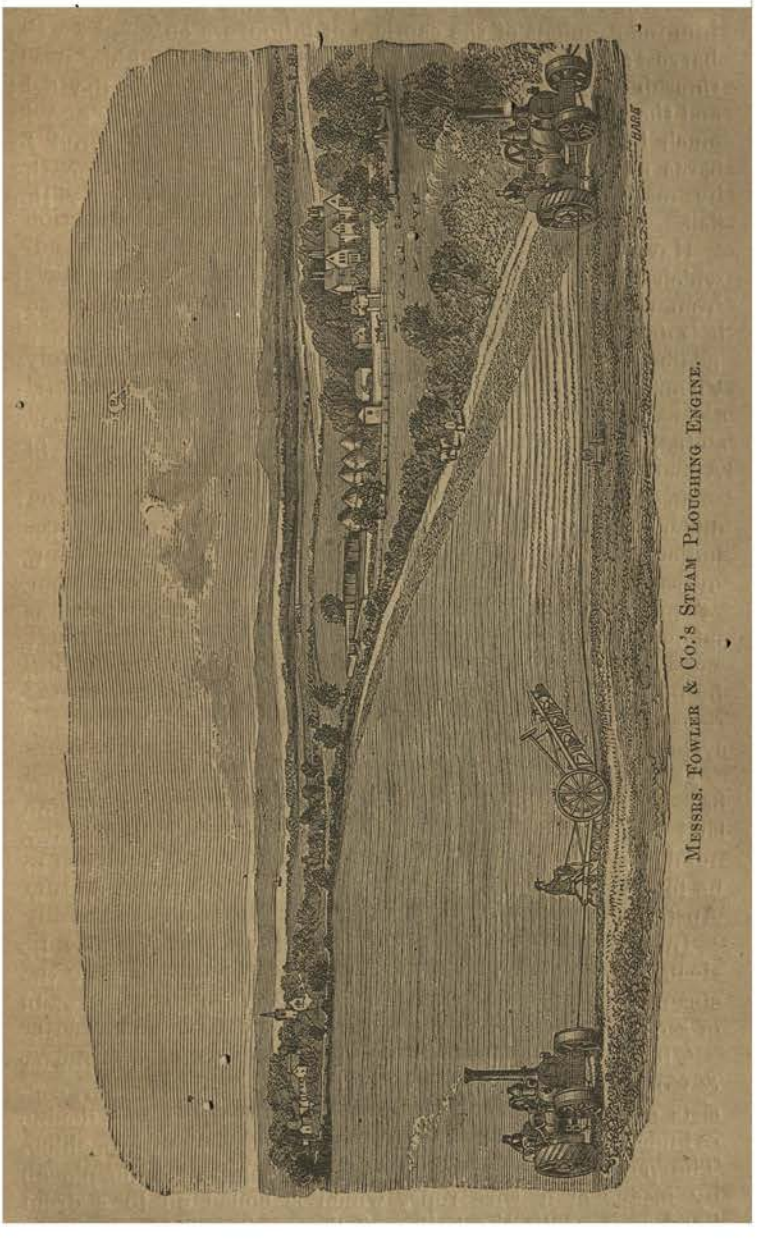
Name of Country.	Steam Plough.	Iron Ploughs.		Wood Ploughs.		Drills.	Horse Rakes and Hay-makers.	Reapers and Mowers.	Steam Engines.				Steam Thrashing Machines.	Horse-power Thrashing Machines.	Food Preparing Machines.
		Single.	Double.	Single.	Double.				Traction.	Portable.	Fixed.	Vertical			
Great Britain -	1	27	10	4	—	23	14	19	6	40	8	10	36	6	71
France - -	—	4	—	1	—	1	—	2	—	8	—	12	3	—	4
German Empire -	—	39	7	49	1	44	8	14	—	4	5	5	3	40	66
Austrian „ -	—	19	1	128	3	50	11	4	—	8	3	2	9	31	67
Norway and Sweden	—	58	1	26	2	4	1	—	—	1	—	—	—	3	12
Russia - -	—	10	—	3	2	2	1	—	—	1	—	—	1	7	4
Belgium - -	—	1	—	4	—	—	—	—	1	—	—	—	—	—	—
Italy - -	1	1	—	47	—	4	2	1	—	1	—	—	1	1	1
Denmark - -	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Switzerland -	—	—	—	—	—	—	—	—	—	—	—	—	—	4	3
Holland - -	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
America - -	—	4	—	9	2	2	2	31	—	—	—	—	—	1	—

The tabulated statement which is here given is most interesting, demonstrating as it does how far the agricultural machinery exhibited at Vienna by Great Britain was in advance of that shown by other nations; for instance, steam ploughs, traction engines, steam thrashing machines, reapers and mowers, &c. are to be found almost exclusively in the Western Agricultural hall, showing that steam is rapidly superseding manual and animal power in all English agricultural operations. On the other hand, although continental nations are progressing rapidly in the construction of advanced machinery, still horse-power and even hand-power thrashing machines, cheap wooden ploughs, ordinary chaff cutters and such like implements abounded in many of the foreign departments.

The manufacture of agricultural machinery is so completely reduced to a science, that the same amount of study and calculation are now brought to bear upon this branch of manufacture as was formerly devoted to designing marine or locomotive engines. The implement manufacturer acts as consulting engineer as well as constructor to the farmer throughout the world, and works out his theoretical ideas in the cheapest and most scientific form, thus producing implements which may be employed economically in comparison with hand labour. In the more remote parts of the continent, however, the village smith puts his rough wood and iron together according to the unmechanical instructions of the farmer, and continuous breakages, wasted time and delay in tilling the land are the results.

It may be said of some of the foreign implement makers who exhibited at Vienna that they do not hold a much higher position than that of a workman executing orders according to sample, instead of being able to improve the position of the farmer by teaching him what implements will be best adapted to his requirements, and proving to him the economy which results from the employment of carefully designed machinery. A farmer soon finds that if a scientifically constructed plough be employed to till the soil the ground is properly brought under the influence of the atmosphere, the subsoil is loosened for the roots and a better crop will result than when the implement is of a primitive construction.

Again, he finds that if the land be carefully and evenly cultivated the seed can be sown by a drill instead of broad cast by hand and economy of seed is obtained, whilst an equitable distribution over the whole area takes place; and again, land which is properly ploughed and sown is much more



MESSRS. FOWLER & CO.'S STEAM PLOUGHING ENGINE.

accessible to reaping and mowing machines which enable the farmer to get in his crops quickly and safely and render him independent of the caprices of labourers engaged for the harvest; and lastly, by the employment of portable steam thrashing machinery the corn may be stacked in the field and the produce sent to market much more rapidly and in much better condition than when the crop was stored in barns and thrashed during the autumn and winter months by means of horse-power thrashing machines, or by the flail.

Having thus touched generally upon the great advantages which accrue to landed proprietors and farmers in general from the introduction of improved agricultural machinery, it is desirable to notice a few of the more striking improvements in this class of machinery which were exhibited at Vienna, although it is not my intention to enter into the details of their construction, as these have been, as before stated, fully described in the "Technical Papers" (*vide* Appendix.)

Steam ploughs.

Space will not allow me to give a history of the mechanical difficulties which have been surmounted and of the prejudices against so startling a change, which had to be overcome before the steam plough attained its present state of perfection. There can be little doubt that as manual labour and cattle are becoming daily more scarce throughout the world, vast tracts of land will be brought under cultivation by means of the steam plough, which would otherwise have remained barren, and land farmed upon the old fashioned system will be materially improved.

It is only within the last few years that the steam plough has been introduced into Germany, generally for use on land cultivated for growing beet root for sugar; a large number are now in use around Magdeburg, and some are to be found in Bohemia, and on a few of the large estates in Austria.

In Egypt natives may be seen ploughing the land by steam for the cotton crop, and it is said that wherever the steam plough has been used in sugar cane culture, the yield of saccharine matter in the cane has been greatly increased.

The steam plough exhibited at Vienna by Messrs. Fowler & Co., of Leeds, who received a Diploma of Honour, consists of two 20 horse power engines, each fitted with double cylinders and arranged so that they are self-propelling. The power is transmitted from the engine, to the plough by means of a wire rope, which is coiled on to a drum fixed underneath the boiler of the engine. One engine is

placed on each headland of the field, and the plough is hauled continuously backwards and forwards, one engine drawing the plough forward, whilst the other slacks out the rope. When the plough arrives at the end of the field, the engine which has been paying out the slack rope commences to pull the plough which makes a fresh furrow, and the engine which previously hauled unwinds the slack wire.

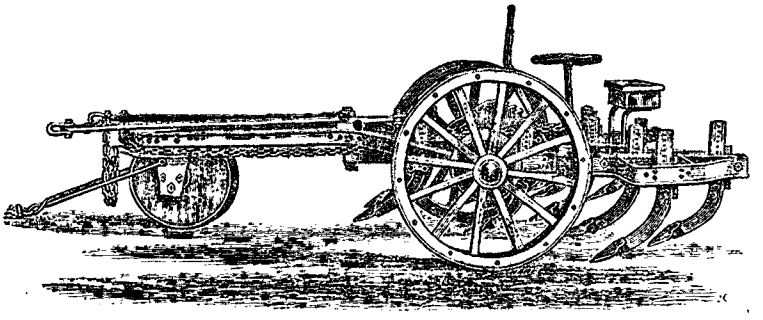
These engines were specially made for the Archduke Albrecht of Austria, and as a provision against scarcity of wood and coal, the boilers were constructed to burn turf, the fire-box and tenders being made differently to the usual standard patterns.

The engines are supplied with large trucks of peculiar construction capable of containing sufficient turf to supply them for the whole day. The plough was made on the patent balance principle, that is to say, four right hand breasts were fixed at one side of a strong wrought-iron frame, and four left-hand breasts on the other side. This frame was made in such a way that, when one set of breasts was at work the others were elevated above the ground at a sufficient angle to clear all obstacles. The whole was carried upon two large wheels placed in the centre, so that one set of ploughs nearly balanced the other, and one man could easily elevate, or depress the ends of the frames. The ploughman, who sits upon the frame, steers the plough by means of an apparatus attached to the moveable arch of the large wheels.

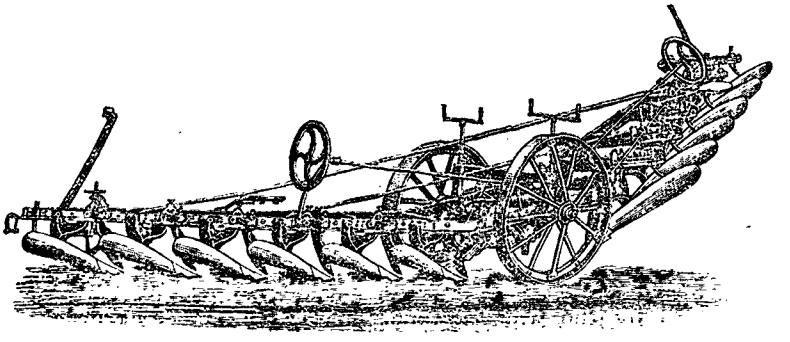
The breasts of this plough are of a peculiar form, very similar to the Ruchadlo type, and they are constructed to work at a depth of from 10 to 12 inches. Messrs. Fowler have also manufactured a new kind of steam plough for the sugar beet districts of France and Germany, in which grubbers are placed behind the breasts, so as to subsoil the ground to a depth of 15 to 20 inches. The other novelty of Messrs. Fowler's stand consisted of a patent turning cultivator, so constructed that a very large amount of ground can be covered by the tines at one time, the implement being easily turned on arriving at the headlands. Messrs. Fowler are adapting their steam ploughs to various systems of agriculture, and also for burning other kinds of fuel besides coal, wood and turf, and two photographs were exhibited of an engine intended for Russia and adapted for burning straw on "Head and Schemioth's" patent.

Iron and wood ploughs for horses and bullocks.

The collective exhibition of implements by Messrs. J. & F. Howard of Bedford was considered by the jury worthy of a "Diploma of Honor." In the single ploughs ex-



MESSRS. FOWLER & CO.'S BALANCE TURNING CULTIVATOR.



MESSRS. FOWLER & CO.'S BALANCE PLOUGH.

hibited by Messrs. Ransomes & Co., Howard, and Hornsby, few novelties were introduced. Some of them were adapted for cutting the rectangular furrow which is usual in English agriculture, whilst others were designed for turning a broken furrow which is generally preferred on the continent. Messrs. Ransomes, Sims, & Head, who were also recipients of a Diploma of Honour for the general excellence of their agricultural machinery, exhibited a large plough suitable for three pairs of oxen, much used in South Russia and the corn-growing districts of the East. It was entirely made of wrought iron and steel, and constructed to turn a furrow six or eight inches in depth and 18 inches broad. As the plough was heavy a small wheel was attached on the side, which enabled it to be easily turned at the headlands. Messrs. Howard exhibited some cheap ploughs similar to those manufactured in Sweden, and also several of their well known single iron ploughs. A very complete ridging plough was shown by Messrs. Hornsby, fitted with markers and hoes, which was considered one of the best implements of the class in the exhibition. The iron ploughs shown by America were not numerous, nor were any remarkable specialities brought forward, but Messrs. Collins & Co. and Messrs. Deere & Co. produced good ploughs at reasonable prices.

During the past few years double-furrow ploughs have made a great sensation among English agriculturists, and are coming largely into use. It is calculated that they save one horse and one man in doing the work of two single ploughs, and a great saving in draft is effected by the use of the friction wheel instead of the slade.

In the double ploughs exhibited by English manufacturers there are various methods of lifting the plough out of work when it arrives at the end of the furrow, so that it may turn at the headland, but they all consist of different arrangements of levers worked by the ploughman, and acting upon wheels or skids placed in the centre or forepart of the plough. Messrs. Ransomes & Co. exhibited a small double-furrow plough, in which the land wheel consisted of a hemisphere, which, when the plough was turned over at the headlands, served as a revolving support to one end, whilst the friction wheel carried the other, thus avoiding any complication of levers and rods.

A large multiple plough was also exhibited by this firm, intended for the corn-growing districts of the East. It was fitted with three bodies, each body ploughing a furrow 10 inches wide, making a total of 30 inches in width. The plough was raised from the ground by depressing a lever

connected with the axle. The wheels were 3 feet 3 inches in diameter, which enabled the plough to be easily transported from place to place.

A few specimens of double iron ploughs were exhibited in the Foreign Department, but they chiefly consisted of two breasts fastened together to one frame without any means of lifting them out of the ground.

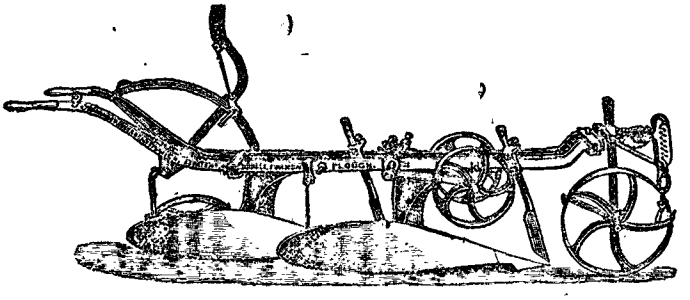
Wooden ploughs were only exhibited by one firm in the English Department, viz., Messrs. Ransomes, Sims, & Head. although there were numerous foreign exhibitors, of whom the most distinguished was Mr. Bernard Eichmann, of Prague (member of the jury). These English ploughs were chiefly improved adaptations of foreign ploughs, suited to the requirements of eastern agriculture. One was on the American system; a second was specially adapted to Bohemia; another a turnwrest plough for hilly countries; and a fourth was on the system of Vidats of Pesth with a wheel fore-carriage, loose on the beam, and various improvements introduced by the makers.

Sweden was especially distinguished at Vienna for excellent iron ploughs at extraordinarily low prices, a well made serviceable plough being obtainable at a cost of from 25*s.* to 50*s.*

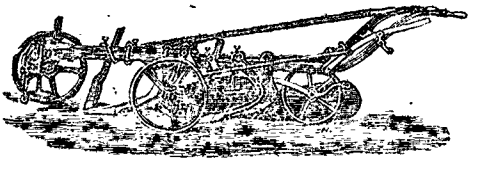
Eckert of Berlin exhibited a very fine collection of ploughs both single and multiple; his breasts were chiefly of the Ruchadlo type, and they were specially distinguished from the English ploughs by having the share constructed of a piece of rectangular steel, sliding in a socket and capable of being brought forward as the front part wears away.

Seed drills. The use of row drills, instead of sowing broadcast by hand, always marks an improvement in the cultivation of the soil, as they cannot be employed when the land is roughly ploughed, and left in broken pieces and clods. In France and Belgium the most improved English drills have been employed for some years and with the most excellent results as regards economy in the quantity of seed required and the position of the grain when it emerges from the ground, each plant being surrounded with the sufficient amount of air necessary for fructification, whereas with the best broadcast sowing by hand it is impossible to avoid delivering the seed in larger quantities in some places than in others.

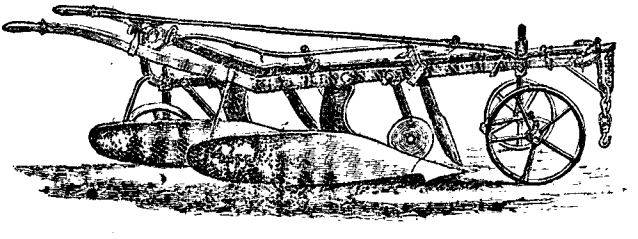
Messrs. R. Hornsby & Sons, Smyth & Sons, R. Garrett & Sons, and Benjamin Reid & Co. (who exhibited "Disc" drills which were highly commended), are the principal exhibitors of drills, some of which are on the broadcast principle, and intended for countries where the old-fashioned



MESSRS. RANSOMES, SIMS, & HEAD'S DOUBLE-FURROW PLOUGH.



MESSRS. HORNSBY & SON'S DOUBLE-FURROW PLOUGH.



MESSRS. J. & F. HOWARD'S DOUBLE-FURROW PLOUGH.

system of cultivation is still in vogue. In France and Germany drills are much used and manufactured, but English patterns have been generally followed in constructing all those which were exhibited in the foreign sections. Germany especially exhibited a vast number of home manufacture, and it is said that very few are now imported into that country. An excellent little drill for sowing pine seed in forest culture was shown by E. Drewitz of Thorn.

Most of the German drills are manure distributors also; and while alluding to these I may here mention, in passing, the excellent pumps for liquid manure displayed in the French section by M. Noel, the inventor, who, as an ordinary workman, conceived the idea of doing away with all valves, and supplying their place with loose balls of india rubber, by which means all stoppages or damage from rubbish, gravel, &c. in the manure are avoided. The pumps are cheap and of great power, and make serviceable fire-engines for the farm or rickyard. In Russia, and in most parts of Hungary, Wallachia, and the large corn-growing districts of the East, row drills have not yet come into general use, but as soon as improved tillage implements are adopted the value of these machines will be appreciated.

Horse rakes and haymakers.

Horse rakes and haymakers are now very generally employed as economisers of labour in all countries where hay is grown, and in spite of the numerous copies of the best English implements shown at Vienna the farmers of France, North Germany, and Austria are said to still prefer those manufactured in England. Messrs. J. & F. Howard have long been celebrated for their horse-rakes and haymakers, and send a large number every year to the continent, especially to France. Mr. Boby of Bury St. Edmunds, exhibited an excellent haymaker, and Messrs. Nicholson, of Newark, construct a cheap haymaker and horse-rake, some specimens of which were exhibited, but although of excellent quality they did not contain any particular novelty. Messrs. Ransomes, Sims, & Head exhibited an improved and cleverly-constructed horse-rake which appears to be coming largely into use on the continent, and as a proof of the appreciation by the foreigners of their implements they pointed to three copies of it exhibited in various parts of the building. These rakes are fitted with steel teeth of large capacity and of an entirely new form, being a T section, which gives great strength and ensures clean raking. They are attached to a rocking frame which, by a simple locking gear, is made rigid when in work. The frame is mounted on high wheels, and a seat can be

attached so that the driver may ride or walk at pleasure. This firm also manufactures an improved haymaker, in which the wheels are very large and the axle is perfectly straight. In addition to these novelties of construction, the machine throws the hay up behind, instead of in front, which in a great measure prevents the clogging of the working parts. Several other horse-rakes were exhibited at various parts of the Western Agricultural Hall, but there were no novelties.

In the American department a very ingeniously constructed horse-rake was exhibited in which the teeth were made of round steel wire arranged in such a way as to collect a very large amount of hay at one time; it was intended principally for use in districts where the grass is very long and rank.

Harrows.

Nothing very remarkable in the way of harrows was exhibited, many specimens both flexible and rigid were, however, shown by various nations, but there were no novelties worthy of special notice, if we except the pulverising harrow exhibited by the New York Plough Company in the American section. It consists of a number of revolving discs of steel let into a wooden frame, the discs supplying the place of teeth in an ordinary harrow.

Cultivators and horse hoes.

Little need be said regarding cultivators. Messrs. Coleman & Morton of Chelmsford exhibited the most efficient looking and best constructed implement. They also showed a potato digger of ingenious design, but as the jury had no opportunity of seeing it in action they were unable to determine whether it actually possessed the merits which the manufacturers claim for it. Numerous cultivators, grubbers, &c. were shown in the foreign sections, none of which, however, drew forth special remark and all were repetitions of patterns which were originally English.

In horse hoes, although there were some excellent implements shown, there was no novelty, or remarkable improvement meriting special notice.

Pulpers, chaff cutters, &c.

The now universally recognized advantage of using root pulpers and cutters, chaff cutters, oil cake breakers, &c. on farms, has called forth much development in the improvement of such implements, but no actual novelties were to be found. Messrs. Richmond & Chandler were the most distinguished for their chaff cutters, and Messrs Albaret & Co. in the French section exhibited a very powerful one with four blades which crushed the straw as well as cut it.

Corn screens, separators, &c.

Corn screens, dressers, separators, and such like machines for preparing grain for market were largely exhibited, and

although no real novelties can be well cited many improvements in details have been effected leaving little to be desired in the perfection of these important economisers of labour.

Messrs. Penney & Co. of Lincoln obtained great credit for their excellent hand implements, such as forks, hoes, rakes, &c.

Reapers and mowers.

There are perhaps no implements which have tended so much to improve the condition of the farmer as Reapers and Mowers. In countries where hundreds of acres of ground are planted with wheat, the success, or failure of the harvest has hitherto depended upon the possibility of obtaining an adequate supply of labour to cut the crops, and hands have been so scarce of late years in many places that the Government have permitted the employment of soldiers, and as emigration and conscription are yearly thinning the ranks of farm labourers on the continent, the importance of harvesting the crops by machinery cannot be over estimated. Many and various schemes have been patented for reaping machines, but a glance at the 70 different specimens exhibited in the British and American sections in Vienna will show that one general principle has been almost exclusively adopted. The usual construction consists of a driving wheel fixed to one side of the machine to which is attached a spur wheel working into a series of small toothed wheels which increase the slow speed of the periphery of the wheel to the fast motion necessary for driving the cutting knives. The knives differ slightly in shape but generally consist of a series of triangular pieces of steel rivetted to a bar of iron in some instances serrated on the edges. This knife bar is attached to a crank by means of a connecting rod, and this crank, which makes about 700 revolutions a minute, receives its accelerated motion through a train of bevil and spur wheels in direct communication with the large driving wheel. The knife bar moves backwards and forwards on guides fixed at the back of a number of pointed fingers, which enter the corn crop and guide the straw to the edges of the cutting knife. A platform is fixed at the back of the cutter bar which receives the corn as it falls from the knives. In most cases a revolving rake with four inclined arms is attached to each machine and set in motion by the main driving wheel. Two of the arms act as gatherers for bringing the corn well on to the knife, and the others as rakes for delivering the cut corn at the back of the machine.

Although many thousands of reapers are used every year in Europe, great obstacles still exist to their general use

in remote parts, where bad cultivation of the soil and the uneven nature of the ground produce an extra strain on all the wearing parts, and cause incessant breakages, whilst if the reaper be made strong enough to bear such strains the draft is materially increased, and it is difficult to find cattle sufficiently strong to draw it for any length of time.

Another obstacle to their use arises from the fact that in many districts labourers cannot be obtained or refuse to bind up the sheaves cut by the machine, and it is in view of overcoming this difficulty that Mr. W. A. Wood of America has designed a reaper with an apparatus for binding each sheaf with wire as it falls from the platform, and although this invention is far from perfect its practical solution will make farmers entirely independent of their labourers, and place the reaping machine upon the same footing as the steam plough and steam thrashing machine. Where reapers have been introduced into eastern agriculture they have tended much to improve the tillage of the soil, as the farmer finds that by the use of good ploughs and drills his land is more evenly cultivated and his crops more regularly sown, thereby avoiding many of the break downs in the middle of harvest which have caused him so much trouble hitherto, and which it was impossible to avoid under the old system of tillage.

The English manufacturers of reapers were not so largely represented as might have been expected, although the principal makers sent specimens of their latest improvements Messrs. Samuelson, Messrs. Hornsby & Sons, and Messrs. J. & F. Howard were exhibitors. Messrs. Samuelson's new "Royal" reaper was a well constructed machine and the weight of the platform was balanced by the driver sitting on a seat attached to a prolongation of the axle on the opposite side. This firm was the first to construct reapers with the present system of self-acting rakes, and their machines hold a high reputation on the continent. Messrs. Hornsby's "Governor" and "Progress" were strong and well built machines, and in many points, especially in the mode of painting and decorating, resembled the American machines more than those of the other English manufacturers. These machines have found great favour in many parts of the continent. Messrs. J. & F. Howard who have only lately commenced the manufacture of reapers, showed their "European" and "International" machines which are carried upon two wheels. The workmanship and general construction of these implements was admirable and fully justify the reputation which this firm has hitherto obtained for agricultural machinery.

The Americans have for some years past had a large share of the supply of reaping machines to Austria and Hungary and parts of Russia, and it is therefore not surprising that the exhibits of agricultural machinery from the United States should be confined in a great measure to Reapers and Mowers, a large proportion being combined machines. The American machines are so well known in the agricultural world that it will be sufficient perhaps to say that their more remarkable characteristics are lightness, which adapts them to the power of small-sized horses, their elegance of appearance as compared with those of other nations, and their comfortable seats provided for the driver, whose weight is made to balance the whole machine, and who has all the gear connected with regulating the rakes, cutters, &c. immediately at his hand.

The only American recipient of a Diploma of Honour was Mr. Walter A. Wood of Hoossic Falls, New York, whose "new champion" reaper and mowing machines are all but perfect. He also exhibited a Reaper with a chain rake which, it is said, has found favour in the United States, but which was not very highly approved by the jury inasmuch as it has the obvious fault of affording no means for insuring regularity in the size of the sheaf where the crop is unequally grown. Mr. Wood also exhibited the machine referred to in the preceding page in which the sheaf is bound with wire as it is reaped.

The Reaper and Binder has only very lately been completed after three years working out of the idea, and at a large outlay of money. Mr. Wood stated to the jury that he has good accounts of the few machines which have been put out to work this year in America, and in the event of acknowledged success, he expects that the demand for them will be as great as that which existed for automatic raking machines, when they first began to supersede those which required a hand rake delivery.

The Reaper and Binder has an endless apron upon which the cut grain falls, and which carries it to the outer side of the Reaper, and deposits it in a trough, where the sheaf is bound with wire and is then tossed clear of the machine by one of the revolving arms which helps to bind it.

The binding operation is very ingenious, and effective, as was demonstrated to the jury by means of a bundle of loose newspapers. Two iron arms which swing from the same centre but in opposite directions, compress the bundle of grain, as would a man's arms, and form a sheaf, the wire is drawn from a reel held by a spring just taut enough to

keep it straight, and is passed round the sheaf by one of the revolving arms at the end of which is a steel twisting gear which meshes into a rack under the trough where the wire is twisted and cut off. The arms are started and stopped by a very simple contrivance which enables the man in charge to regulate the size of his sheaf.

Messrs. Aultmann, Miller & Co.'s Reaper fitted with a revolving table rake was a novelty of which the jury saw no reason to approve. The "Johnston" rakes of which there are many varieties do their work so well and are so capable of being regulated in their working, so as to insure uniformity in the size of the sheaf, that neither chain nor revolving table rakes appear likely to supersede them.

The American trade in agricultural implements with Australia has very much declined of late years owing to non-residents in the Colonies being unable to protect themselves by patents. It is said, however, that out of about 100,000 reapers and mowers constructed annually in the United States about 12,000 find their way to Great Britain and the continent.

The question as to whether a benefit, or the reverse is conferred on the agriculturist generally by the construction of the combined reaping and mowing machines was frequently a matter of discussion among the jury. Some were in their favour, but others were of opinion that the benefit is exceptional and confined to the very small farmer. It was argued that a well to do man would probably do better if he were to invest his capital in the first instance in two machines, a Reaper and a Mower, both of which would always be available for use and would never be subjected to the trying operation of changing at unmechanical hands. He would thus get the full number of years' work out of both implements; but from motives of economy he is tempted to buy a combined machine at two-thirds of the cost, and he finds that he not only incurs delay in cutting crops which he could get in if he possessed two implements, but he has always the risk of damage and expense for repairs consequent on the frequent changes necessary to his single combined machine.

Steam thrashing machines.

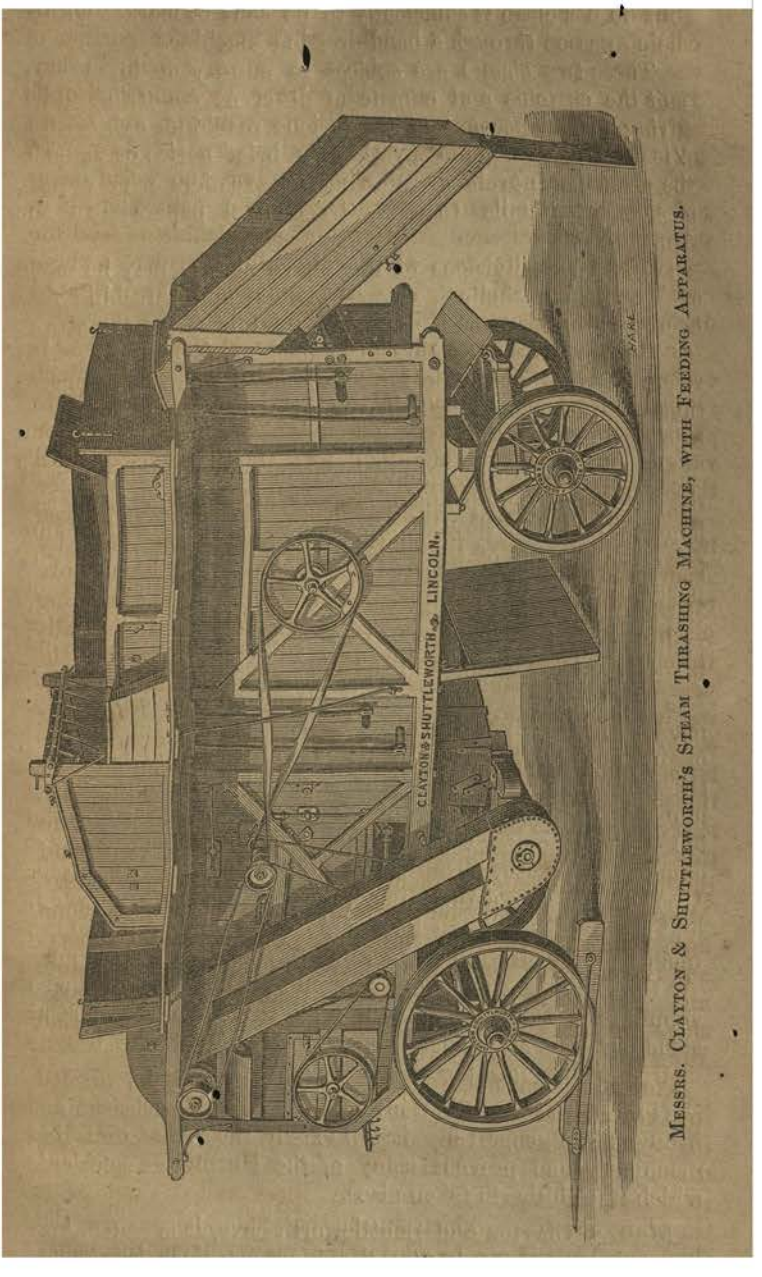
A reference to the table at page 171, shows that Great Britain exhibited nearly double the number of steam-thrashing machines shown by all the other nations put together, and it may be stated generally that all those which were exhibited in the foreign sections were, more or less, copies from the best English patterns.

From the earliest ages grain has been trodden out by cattle or horses, and to this day the greater portion of the corn grown in hot countries, such as Spain, Turkey, Italy, Mexico, &c. is so thrashed, or else by some such rude contrivance as a roller studded with stone or iron, and drawn over the sheaves by oxen on a hard sun baked floor. In such a case the operation is a double one, the grain being not only separated from the straw, but the straw itself is macerated and softened so as to be serviceable as food for the cattle, in lieu of hay, which can only be grown in those countries in situations where the ground can be irrigated during the hot season.

In the northern part of Europe, however, where grass is everywhere to be found, and where straw is not so much required as an article of food for cattle, it is desirable to preserve it as much as possible in an unbroken state for various purposes, and the flail was therefore used until thrashing machines were invented.

The first machines with a drum and concave driven by water power were, I believe, made in the year 1785 by Andrew Meikle, a mechanist of East Lothian, but it was only towards the beginning of the present century that thrashing machines driven by horse power began to spread gradually through the country, and they were in general use until the year 1845, when the first portable steam engine and thrashing machine were exhibited at Bristol by Messrs. Ransomes & Co., but steam power did not find much favour with the farmers until after the year 1850. The first double-blast thrashing-machine which proposed to clean the grain perfectly, so that it could be put into sacks and sent direct to the market, was brought out by Mr. Burrell in 1848, and this machine was subsequently developed and improved by Messrs. Clayton and Shuttleworth, who have, perhaps, done more than any other firm to perfect this class of machinery, and the model of the large number of thrashing machines and engines which issue annually from the Lincoln workshops may be said to have emanated from the Stamp End Works.

Thrashing machines of the present day may be divided into two classes; firstly, those known as double-blast finishing machines, which not only perfectly clean the grain but divide it into different samples, each one of which is placed in a separate sack; and, secondly, those called single-blast thrashing machines, which thrash the grain and separate the chaff, chobs, and principal foreign matter from the corn;



MESSRS. CLAYTON & SHUTTLEWORTH'S STEAM THRASHING MACHINE, WITH FEEDING APPARATUS.

but do not clean it sufficiently to be sent to market without being passed through a hand-dressing machine.

These two classes are subject to sundry modifications to suit the customs and climate of different countries, and in giving a short account of the various machines exhibited at Vienna I shall confine myself to a brief notice of some of the principal novelties, referring my readers who require mechanical details to the "Technical papers" in the Appendix.

Several sub-divisions of the above classes may be made such as maize shellers, clover drawers, and thrashing machines with apparatus for chopping and bruising the straw, for hot countries, rice thrashing machine, &c., all of which require certain mechanical alterations to effect these operations; but the main principle of construction in all these machines remains the same.

Messrs. Clayton and Shuttleworth, who are also one of the recipients of a Diploma of Honour, exhibited certainly the largest number of thrashing machines of various sizes and powers, and many of them specially adapted to the requirements of Eastern Europe. The general construction of those exhibited was similar to the machines of this firm, so well known in Hungary, Austria, and the corn-growing districts of the Danube, and the chief novelty to be remarked was an apparatus or "feeder" placed on the top of the machine for supplying the drum by mechanical means instead of by manual labour, in which latter case the workman takes the cut sheaves in his arms and feeds them gradually into the mouth of the drum. This apparatus fixed on the top of the machine, consists of shaking boxes worked by a crank underneath, furnished with wooden ratchet teeth. Upon this reciprocating frame the cut sheaves are placed, and are gradually carried forwards until they drop into the mouth of the drum, in the same way as if fed by a man. As the drum is completely covered over, and the man, who supplies the feeding apparatus with the sheaves, stands at some distance, all danger from the breakage of the beaters or from falling into the machine is avoided.

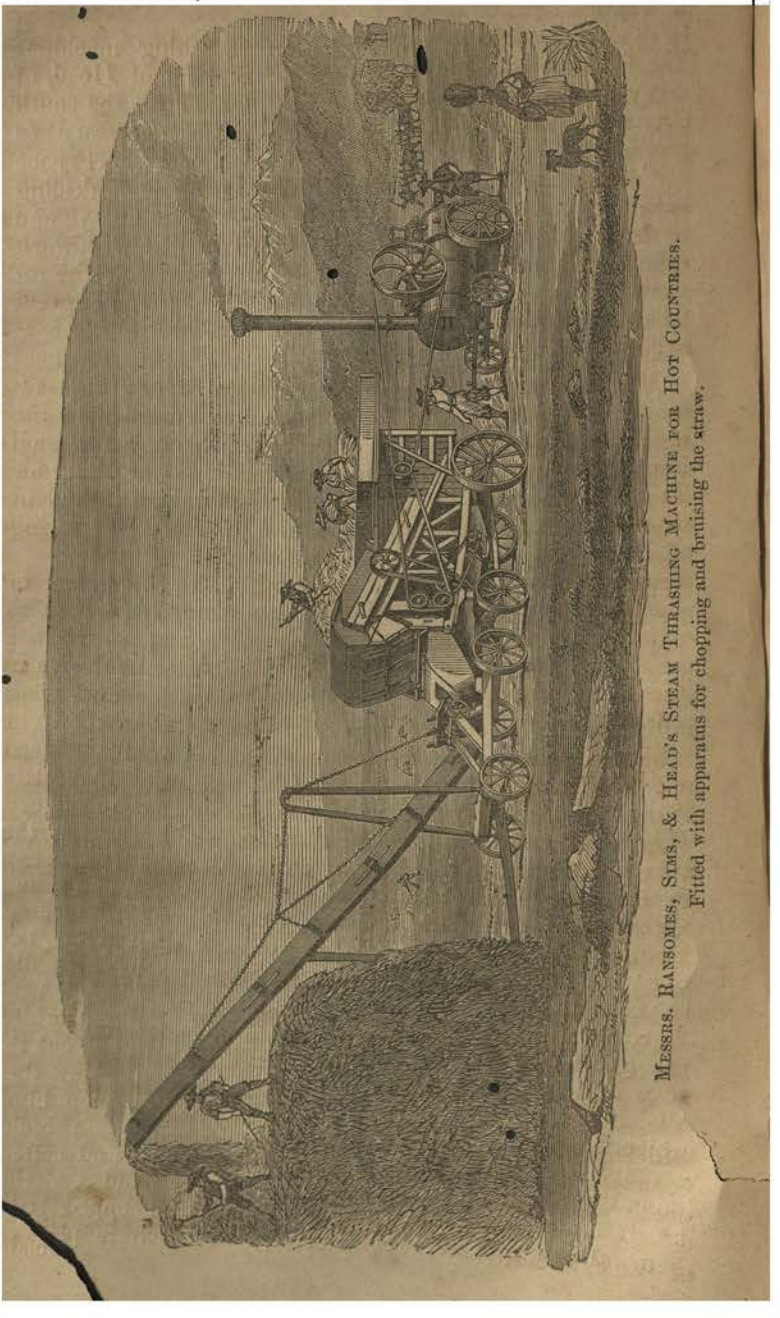
No doubt when this invention is more perfected and brought into general use, it will extend the use of thrashing machinery and prevent many of the lamentable accidents which have hitherto taken place.

Messrs. Clayton and Shuttleworth have, it is stated, constructed upwards of 10,000 thrashing machines, large num-

bers of which are at work in Austria, Hungary, and the Principalities.

Some of the greatest novelties in thrashing machines were exhibited by Messrs. Ransomes, Sims, and Head, of Ipswich. One of these was specially intended for the south of Russia, and other localities where it is necessary to thrash an enormous quantity of grain in a very short space of time, and this machine was said to be capable of dealing with 1,200 to 1,500 sheaves per hour, yielding on an average from 90 to 120 bushels of clean corn. All the woodwork was fitted together in the most scientific manner; the rotating parts are of very large diameter, with bearings of great surface in order to avoid wear, and the oiling arrangements are so made that the bearings do not require frequent replenishing. The dangers of a break down are thus reduced to a minimum, a matter of vital importance to the Russian farmer, who employs many labourers with each machine, and having only a limited time for thrashing his grain could not afford the delay consequent upon an accident while the broken parts are sent to the nearest repairing shop which is often 100 miles distant.

The above firm were the only exhibitors at Vienna of thrashing machines to be used in hot countries, where, as before stated, it is necessary to macerate and soften the straw so as to make it fit for fodder. The straw grown in Italy, Spain, Turkey, &c. is so much harder and more brittle than that produced in cold countries, that when cut with a chaff-cutter in the ordinary manner it cannot be used for food without seriously injuring the palates of the cattle consuming it, and an ingenious machine has been designed by Messrs. Ransomes, Sims, and Head, which thrashes the grain and at the same time prepares the straw as when trodden out by cattle, both operations being carried on simultaneously. It resembles the ordinary double-blast machine, but at one end where the straw passes over the shakers, two rollers are placed one over the other, which revolve rapidly. The straight straw after leaving the machine falls upon the top roller, which is furnished with long sharp knives working into a concave studded with similar knives which cut the straw into lengths about 1½ inch long. The cut straw then falls on to the second roller, which is fitted with square blunt projections working into a concave of a construction similar to that of the roller. This cylinder macerates and softens the cut straw, taking off all the sharp edges, and rendering it soft and agreeable to the mouth. The chopped straw then falls into a sort of reservoir, in which is placed a



Messrs. Ransomes, Sims, & Head's Steam Thrashing Machine for Hot Countries.
Fitted with apparatus for chopping and bruising the straw.

powerful fan which blows it through a round tube about 30 feet in length on to the top of the stack. This tube can be elevated, or lowered according to the height of the stack. The fodder made by this machine is preferred by cattle to that which is trodden out, it being entirely free from dung, dirt, and dust, which naturally accompanies the latter process.

A second machine on this patent was also exhibited by the same firm, but of a smaller and lighter type. The grain to be thrashed is placed direct into the chopping and bruising cylinders without the intervention of the ordinary drum and straw shaker. This machine is intended only for mountainous countries and districts where straight straw is never required.

Messrs. Robey and Company exhibited several thrashing machines of various sizes, the principal and most interesting novelty in their construction consisting in the use of angle iron for the frame of the machine instead of oak or pitch pine. These machines are said to be rather lighter and stiffer than those of the ordinary construction, and the frame when made of iron is not so liable to be damaged by changes of temperature as when made of wood. The only objection which can be put forward to using iron framing, is the difficulty, which may sometimes occur, of finding workmen in the distant parts of the country to which these machines are often sent, who understand working in iron, whilst a carpenter is always to be found at almost every village.

Messrs. Marshall exhibited a thrashing machine which was fitted with an angle iron frame, with the sides made of sheet iron, instead of as in Messrs. Robey's of deal boards. This arrangement is a very excellent one for machines which are often exposed to the heat of an almost tropical sun; but the expense of construction may possibly militate somewhat against their general introduction.

Messrs. Ruston, Proctor, & Co. exhibited the only steam maize thrashing machine in the English department. The heads of maize are placed in a hopper at the top of the machine, from whence they fall into a cylinder studded with blunt projections, in which revolves a close drum also covered with rows of similar studs arranged in the form of a screw. The action of the rotating cylinder upon the maize heads, which are kept in continual motion between the drum and concave, tears off the kernels which fall into a sieve underneath where the dust and dirt are extracted from them; the cobs, or soft portion of the maize heads fall out at the end of the cylinder.

Although many horse-power thrashing machines were exhibited in the continental sections, very few were shown in the English department, and the only one worthy of attention was one manufactured by Messrs. Wallis and Steevens, which was intended to be worked by four horses. The thrasher and horse gear were both neatly arranged on a four-wheeled carriage, so that they might easily be transported from place to place.

A very few words will suffice regarding thrashing machines exhibited in the foreign sections. France had a few steam thrashers, as well as several worked by horse-power, Albaret & Co. and Del Ferdinand being the only important exhibitors. Their machines have no new specialities, or improvements worth mentioning, excepting that much importance is placed upon the delivery of the straw in an uninjured state. The workmanship of the above two firms is excellent, as is also that of Mr. Eichmann, of Prague, and Mr. Hofherr, both of whom exhibited largely, and Mr. Lanz, of Mannheim, also showed some good machines. Hand-power thrashing machines also found a place amongst the foreign exhibits, but they require no comment.

Traction engines.

Although traction engines were examined by the jurors of Group 13, a few words regarding them are necessary on account of the important part which they are likely to play in the future history of agricultural machinery.

Messrs. Aveling & Porter, Messrs. Fowler, and Messrs. Clayton & Shuttleworth were the only exhibitors, if we except Messrs. Bede & Co. of Verviers, who showed a traction engine, fitted with india-rubber tyres on R. W. Thomson's patent, but which was considered unsuited to agricultural purposes. All the English traction engines were fitted with locomotive boilers with the cylinder on the top of the boiler, the transmission between the engine and wheels being effected by spur gearing. The driving wheels had diagonal strips fitted to the tires for increasing the adhesion.

Messrs. Aveling & Porter exhibited two engines one of which, fitted with a crane, was employed by the British Commission in hauling heavy goods from the railway to the building, and it was found of great practical utility contributing in no small degree to the early completion of the British section, and again after the close of the exhibition it did most valuable work in loading the trucks with empty cases at the place of storage.

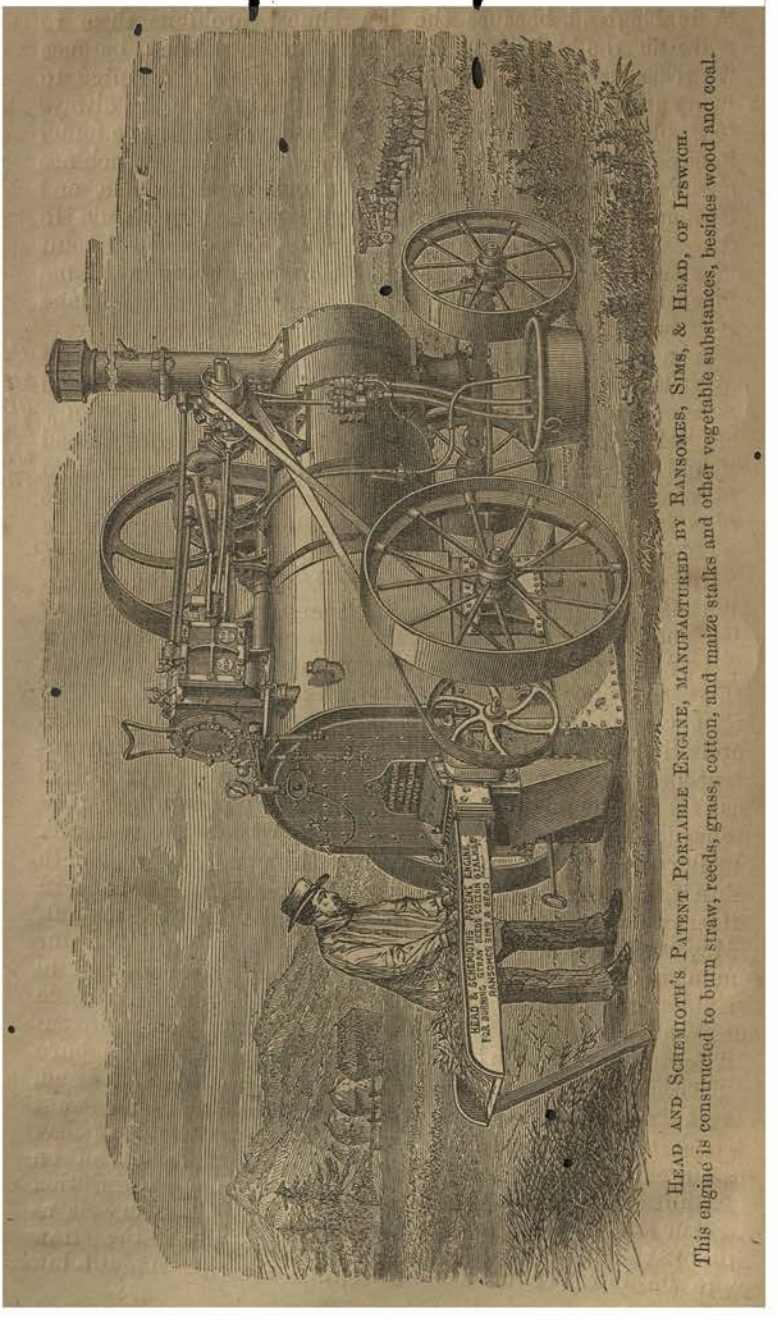
These engines have been but little used up to the present time in the eastern and other remote parts of Europe, not,

as in England, because the law almost prohibits them to move on the highways, except at stated hours, but because the roads are uneven, badly metalled, and little adapted to heavy transport, water is scarce, and good fuel is not always to be obtained, and, in addition, cattle may generally be found in any number at cheap rates for hauling thrashing machines about. Besides all this, skilled labour is expensive, and traction engines require a more experienced mechanic to drive them than portable engines. In an economical point of view it is generally supposed that, unless cattle become much more scarce and expensive, the present system of haulage is much cheaper than by steam on common roads.

Portable steam engines for burning straw as fuel.

The large group which comprised portable engines was also placed under the head of steam engines in general and was consequently examined and reported upon by the jury of Group XIII. One portable engine only was examined by our jury, as it was essentially constructed for agricultural purposes, and contained such important improvements as to place it under the head of a novelty. The engine referred to is one of 10-horse power adapted for burning straw, reeds, cotton stalks, &c., invented by Mr. Head and Mr. Schemioth, and manufactured by Messrs. Ransomes, Sims and Head, of Ipswich, England.

In most countries where different crops are grown on the same farm, and also in farms situated near large towns, straw is very valuable, not only for sale but for manure, fodder, and other purposes, and it would naturally be more advantageous to pay a good price for the wood and coal required as fuel for the engine employed in thrashing operations, than to consume the straw which could not be easily replaced. In the great plains of Hungary, the Principalities and South Russia, however, where the cultivation of cereals is far in excess of that of any other crops, the residue of straw left, after making ample provision for the farm-yard and for manure, &c., is so great that large stacks are allowed to rot or are burnt. In these countries fuel is generally scarce and expensive, and under these circumstances the invention of an engine which will enable the farmer to burn fuel which he grows himself and which is always at hand, must be hailed as a great boon, and supplies a want which has long been felt in districts where steam power is urgently required, but could not be made use of on account of the scarcity of fuel. A succinct description of the invention given by Mr. Head to the Jury is as follows: "The theory of the invention is that the straw "to be burnt should be forced into the fire-box, at a low



HEAD AND SCHEMIOTH'S PATENT PORTABLE ENGINE, MANUFACTURED BY RANSOMES, SIMS, & HEAD, OF IPSWICH.

This engine is constructed to burn straw, reeds, grass, cotton, and maize stalks and other vegetable substances, besides wood and coal.

" level by means of rollers, in a thin stream, somewhat in " the shape of a fan and held there in suspension, so that " the flame can completely surround each piece. A sufficient " quantity of atmospheric air is admitted into the bottom of " the furnace, so that a proper combustion is kept up. The " bars are kept free from silica by means of knives " which are worked backwards and forwards and are " completely under the control of the stoker. A water jet " is attached to the feed pump so that the heated ashes are " quenched immediately they fall, thus precluding any dam- " age from fire. These engines require about 7 or 8 sheaves " of straw to thrash 100 sheaves of wheat, and from a great " many experiments, which have been made, it is found " that it requires from 3½ to 4 lbs. of straw to produce the " same result as 1 lb. of coal."

" Many of these engines are in work in South Russia " and some in Hungary, and the most satisfactory accounts " have been received of their performances during the past " year, and it is calculated that they effect a saving of nearly " 2*l.* a day in thrashing. During the past year several of " these engines have been sent to India for burning indigo " stalks as fuel, and they have also been tested with the most " complete success for burning cotton stalks in Egypt; a " problem which engineers have attempted to solve for many " years past, but hitherto without success."

The scarcity of fuel in some parts of India and Egpyt is well known, and the possibility of converting their refuse material into fuel must tend more than anything else to enable the landowners to introduce steam power into districts where its value has, from force of circumstances, not yet been appreciated.

An interesting account of a trial made at Ipswich with this engine may be found in "*Engineering*" of the 23d May 1873, and a more recent one took place before a number of scientific men at Vienna during the time of the Exhibition, a description of which was published in the " Wiener Landswirthschaftliche Zeitung " of the 23d August 1873.

The section of the jury on which the examination of the agricultural machinery devolved was fortunate in having so eminent a man as M. de Tisserand as its President; and when I undertook to write these notes I asked him to favour me with some of his observations on the progress which has been made in France and other countries since the Paris Exhibition of 1867. As he permits me to make any use which I like of his very interesting reply, I take

the liberty of adding a translation of it here, feeling sure that the opinions he expresses regarding the machinery of England cannot fail to be gratifying to British exhibitors. Indeed it was a source of no small feeling of satisfaction to myself as a British member of the jury to hear the same high opinion and approval of all the machinery of this country constantly expressed by my foreign coadjutors.

"MY DEAR COLONEL,

"TOUCHING your request to me for a note of some of my observations on agricultural machinery, and the progress realised since 1867, and before answering your questions, I wish to enunciate the principle that *progress is the consequence of want*, and that agriculture, like all other industries, modifies her old customs only when driven to do so by imperious necessity. Agriculture has often been reproached with progressing less rapidly than other industries, but on this subject much can be said to show that this reproach is unmerited. To start with, the cultivator of the soil, besides being dependent on the elements, is merely an auxiliary of nature, and in the production of a quarter of wheat, or a stone of meat his labour is a minute fraction as compared with the work which nature puts forward in his aid. As regards all other industries the work of man is everything. Once that a manufacturer has converted a pound of raw cotton into thread, he is enabled with the aid of his machinery to do, now-a-days, work in one day, which would have employed 100, or 200, or even more men.

"Moreover such necessities are far more keenly felt on other industries than that of agriculture, although the latter occupies at least two-thirds or perhaps three-fourths of the population of the globe. Its capital is immense, and it naturally is not susceptible of rapid modifications and changes.

"Hence the slow growth of agricultural progress.

"A Legislative Act may modify, or utterly overthrow the arrangements of some industries, as has been shown in France by the effect produced, by the treaty of commerce on the trade in metals, but the law is powerless to effect such a sudden change on a system of agriculture; its progress is effected by gradual modifications of the conditions of society, such as increasing communications, increase in the cost of the necessaries of life, and the growing scarcity of labour of men who have been drawn to towns and centres of manufacture. Examine for instance the history of any machine, say, 'the Mower,' it was invented in 1826 or '27 by Patrick Bell of Forfar in Scotland; why did it remain so

long unused? Simply because manual labour abounded and agriculture required no mowing machine. Nearly 30 years later, America, driven by want of labour reproduced Patrick Bell's machine, and the Reaper of MacCormick created a tremendous sensation in the London Exhibition of 1851; but it was comparatively little used till of late years, when manual labour being almost unattainable it has spread everywhere. The history of the thrashing machine is almost precisely the same. I now arrive at the questions you have put to me. I cannot say that I observed any important novelty in agricultural machinery exhibited in the Prater. As regards France I would mention an apparatus hardly yet complete, namely, 'the œnotherm' of Mons. Terrel Deschênes for heating wines which are difficult to keep, or which do not bear transport well without altering their ordinary condition. A French savant Mons. Pasteur during his researches into the changes of wine, arrived at the determination that a parasitical vegetation, and the presence of an organic being, of the genus Micoderm, is the cause of all ills in the manufacture of wine."

"Mons. Pasteur experimented by heating wines to a temperature of 50 or 60 degrees Raumur, and found that the germs and parasites were thus destroyed, and that the wine could then keep and travel without fear, besides that he found that the process of heating ripened and improved the wine. The next step was to find an economical method of heating the wine and cooling it again without exposing it to the contact of the air. Mons. Terrel Deschênes invented the apparatus which I now point out to you as the best œnotherm known.

"I have only now to notice French machinery. For instance, the great progress made in oil and wine presses. Up to within the last few years the greatest possible pressure was all that was thought of, but as it became known that in pressing certain oleaginous grains it was desirable not to press beyond a certain point, Messrs. Mabile & Samain have applied a simple contrivance to their machines, which nullifies the action of man after a certain limit, as the lever then is thrown out of gear without any attention on the part of the workman. I may also mention a small hay press of Mons. Le Duc, and the excellent liquid manure pumps of Mons. Noel, a simple workman from our school of arts and industry, who invented this pump, in which valves are done away with and replaced by balls of india-rubber, so that gravel, mud, or rubbish from the manure cause no obstruction; they are also remarkably cheap. I would also cite the weighing

machines of Mons. Paupier, which unite great precision with cheapness, they are of such a finish as to place them quite at the head of all weighing machines.

"In the American section we found almost nothing except 'Mowers and Reapers,' but how these machines have been improved! We saw them all in action at Leopoldsdorf. The combined 'Reaper' of Warder Mitchell & Co. Johnston's 'Reaper' and Wood's 'Mower' worked the best of all. I will merely allude in passing to the 'reaper' invented by Mr. Wood, which not only cuts the grain but binds it in sheaves. The machine exhibited, although full of the idea, does not quite present a solution of the problem, but there can be little doubt that the people who invented the sewing machine will end by presenting to the world one that reaps and binds corn ready for carriage.

"In the English section one sees every effort made, and indeed considerable progress realised in the matter of improving the construction of machinery. The English manufacturers have very wisely devoted great attention to modifications to suit the requirements of other countries, namely Austria, Russia, Roumania, &c.

"One of the improvements most remarkable is that which has been effected in thrashing machines; as far as working is concerned they seem now perfect. Receiving the grain in the ear they turn it out perfectly clean, sorted and measured ready for the market, and they thrash large quantities of grain. Formerly one could reproach the best machines with being easily put out of order, and requiring frequent repair; but the English mechanics now brace their machines with iron, which protects them against warping and shaking.

"I should mention under this head the thrashing machines of Messrs. Clayton & Shuttleworth, Messrs. Ransomes, Sims, & Head, Messrs. Ruston & Proctor, and Messrs. Robey, who have all devoted a great deal of attention to improvements for the more regular and easy working of their machines, and who have all adopted the most improved screens for distributing the grain perfectly separate according to the quality. Messrs. Ransomes, Sims, & Head exhibit a locomotive suited to the want of countries where fuel is scarce and straw valueless, such as Southern Russia, Hungary, and the banks of the Danube. All the English machines are so well known and exhibited by houses of such renown, that it is useless to dwell any longer on the English exhibition, which shows an incontestable superiority over the sections of all other countries at the Universal Exhibition of 1873 on account of the finish of the work and

the mechanical value of the implements. Germany, Austria and Hungary had a remarkably numerous exhibition, but I observed nothing new; I merely remarked the general tendency to progress in Germany shown by the increased number of agricultural machines. A real progress is observable when comparing their show at Vienna with that of Paris in 1867.

"Another remarkable fact is the great increase in the fabrication by the Germans of 'Drills' for sowing cereals, beetroots, &c. in line.

"Austria and Hungary had the good fortune to see established at Vienna and Pesth two great English houses, Clayton & Shuttleworth at Vienna, and Robey at Pesth, thus the construction of agricultural implements in these two countries has received a great impulse, of which the honour falls back to England.

"Switzerland, Italy, and Belgium have exposed nothing worthy of notice. Sweden deserves mention for the excellent construction of her iron ploughs of good quality and exceedingly low price. It is extraordinary that they can furnish excellent iron ploughs at prices varying from 25*s.* to 50*s.* This country should certainly command the market of the world. Such, my dear Colonel, are my principal observations on the agricultural machinery. There are hardly any real novelties of importance, but in the matter of improvements much has been done.

"The manufacturers have striven to imitate those of England, and their machines are consequently better made and better finished. Germany, Hungary, France, Sweden, and Switzerland are especially distinguished in this respect. Russia, Italy, and Spain have not made a corresponding progress since 1867; indeed one may say that Italy was better represented in 1867 than in 1873.

"You have asked me for *brief* notes; perhaps I have made them too brief; but I send them as they are, quite at your disposition to develop them if you wish to do so.

"Receive, my dear Colonel, with the expressions of the pleasure I have had in making your acquaintance, and in working in common with you, the assurance of my high esteem.

"(Signed) EUGENE TISSERAND.

"P.S.—During the last few years the sale of agricultural machinery in France has increased enormously. Mowers and Reapers have been sold in thousands since 1870, and in the 14 departments of the N.E. and South more than 2,000 were bought in 1872.

"Drills have multiplied also considerably, and, moreover, the steam thrasher is everywhere being substituted for the ordinary hand machines; on lands where the cultivation is limited private persons of enterprise have established machines for thrashing, which they take from farm to farm."

In concluding my superficial remarks upon the agricultural machinery exhibited at Vienna, I would not have it understood that the English exhibitors are so far in advance of their foreign competitors that they may rest from their labours, and hold the monopoly for the future supply of machinery to those countries which they have so largely benefited; far from it—the splendid display of ingenious and well constructed English implements at Vienna has awakened the foreigner to a sense of his own shortcomings, and many mechanical engineers are preparing to enter the lists in competition with England. It is hoped therefore that our manufacturers may be stimulated to still greater exertions for maintaining the prestige which England now enjoys.

The visitor to the agricultural department of the Vienna Exhibition had a remarkable opportunity, such as has probably never occurred before, of realising in his own mind, by the evidence of his eyesight, the extraordinary progress which has been made in the development of machines and implements for agricultural purposes within the present generation, for in some sections, and especially in the outer annexes and sheds attached to the eastern "Maschinen Halle," were displayed a collection of instruments of husbandry which are still in active use in the remote parts of Eastern Europe, in districts where the farmer may perhaps have heard of an iron plough, but has certainly never seen one, many of these were of the rudest and most primitive description, and the members of the jury themselves were fairly astonished at finding such implements exhibited as specimens of European manufacture; indeed, some of them could hardly bear favourable comparison with an interesting collection of models of primitive ploughs, drills, harrows, &c. exhibited by the Government of India, illustrative of the rude appliances with which the natives still till the soil and have tilled it from time immemorial.

Mr. J. H. CUNDALL.

MACHINERY LENT TO COMMISSION.

Report on Machinery lent to the Royal British Commission for use in the Exhibition. — By J. H. Cundall, Esq.

The machinery exhibited at the Vienna Exhibition was nearly all placed in one long building, 2,952 feet in length by 160 feet in width, giving an area of 472,320 square feet. Of this space Great Britain was allotted 352 feet in length by the width of the building, giving an area of 56,320 square feet. This gallery or hall was divided longitudinally into one grand nave with a clear span of 92 feet, and two side aisles, divided from the principal gallery by piers and arches which carried the roof of the latter.

Two parallel lines of shafting were erected by Austrian authorities in the principal gallery, in such lengths as were repuired by the different countries exhibiting machinery. In the British section it extended nearly the whole length. This shafting was 3½ inches in diameter, and was carried on two lines of cast-iron columns 29½ feet apart, and braced together at the top with wrought-iron girders. All machinery which required to be driven, except that using steam only, had therefore to be placed in the main gallery.

In the British section this shafting was driven by five horizontal engines, lent to Her Majesty's Commissioners for that purpose by the following firms :—

Mr. J. J. Derham, Blackburn, one 35 horse-power condensing engine, and one 30 horse-power high pressure engine.

Messrs. W. and J. Galloway and Sons, Knott Mill Iron Works, Manchester, one 35 horse-power compound high and low pressure engine (indicated 100 h.p.).

The Reading Iron Works Company, Reading, one 25 horse-power condensing engine.

Messrs. Charles Powis and Co., Cyclops Works, Millwall Pier, a pair of 10 horse-power high pressure engines, coupled.

Giving a total of 145 nominal horse-power.

The cost of the transport out and home of the engines was undertaken by Her Majesty's Commissioners, with the understanding that if the engines were sold in Vienna the cost of the transport out was to be refunded to them. Owing to the financial crisis, and the consequent stagnation of trade in Austria, all the engines had to be returned to England. The foundations for all the engines were executed by and at the cost of the Austrian General Direction.

The power in every case was transmitted to the shaft by a 12″ double-ply belt, which worked on to a wrought-iron drum fixed on the shaft. The drums had to be made in halves, as the shafting could not be moved from its bearings without great labour. They were manufactured by Messrs. Hudswell, Clark, and Rogers for Her Majesty's Commissioners. The shafts were driven at 120 revolutions per minute.

The steam for the above engines was genorated in six boilers, which were placed in a house on the northern side of the Machinery Hall, and about the centre of the British section. The boilers were lent by the following firms:—

Messrs. W. and J. Galloway and Sons, Manchester, two double flued patent "Galloway" boilers, each 40 horse-power.

Messrs. Adamson and Co., Hyde, near Manchester, two double flued patent boilers, each 40 horse-power; the shell of one of which was made of steel.

Messrs. J. and F. Howard, Bedford, one patent tubular boiler, 50 horse-power.

Messrs. Cater and Walker, Southwark, one patent multitubular boiler, 50 horse-power.

Giving a total of 260 horse-power.

The setting of the boilers was undertaken entirely by the General Direction, but the boilers had to be lowered into place and the brickwork to be superintended by the British Commission. The transport was also undertaken by the Austrian authorities on the same conditions as those made by the British Commission for the transport of engines. Five out of the six boilers were sold, one to Russia, one to Italy, and three to Austria, the sixth had to be returned to England.

Besides the engines already mentioned, steam had to be supplied for various machinery, such as steam hammers, steam pumps, a brickmaking machine, an ice making machine, a calico printing machine, a wool washing machine, and other smaller exhibits. As it seldom happened that the different exhibitors required to work their machines at the same time, four boilers were generally found to be sufficient to supply the necessary amount of steam. The coals, which were supplied free by the Austrian General Direction, were of a good quality and almost equal to those in general use for steam purposes in England; the consumption averaged five tons per day of nine hours.

The feed water was supplied to the boilers by three feed pumps and one injector, lent by the under-mentioned firms:—

Messrs. Hayward Tyler and Co., Upper Whitecross Street, London, Double-acting Steam Pump.

Messrs. Brown Brothers and Co., Edinburgh, Steam Pump.
Messrs. Brotherhood and Hardingham, Compton Street, London, Patent Paragon Steam Pump.
Messrs. Sharp, Stewart, & Co., Atlas Works, Manchester, Brass Giffard Injector.

These three pumps and injector were all connected to the same steam pipe, drew their water from the same water main, and discharged into the same feed pipe which was in connexion with all the boilers. By these means any of the pumps could be shown at work when wanted. Of course the feed power was in excess of that actually required; but, as several firms were anxious to show their exhibits at work, it was decided to accommodate as many as could be conveniently placed in the boiler house.

The steam was conveyed from the boiler-house to the Machinery Hall through wrought-iron pipes, manufactured by the Brünner Zucker formen Blechwaaren und Maschinen Fabriks Gesellschaft, at Brunn, in Austria. These pipes were made from sheet iron about $\frac{1}{16}$th of an inch thick with flush rivetted and brazed joints, a flanged piece was rivetted on each end of the pipe, which kept in place a loose wrought-iron collar, through which the coupling bolts passed. A double conical bush or collar was placed inside the pipes at each junction, so that as the pipes were screwed together they tightened on the cones, and this, with the aid of india-rubber rings between the flanges, was found to make a very good steam-tight joint.

The boilers were connected by a 10-inch steam main, which extended across the boiler-house and into a trench that ran parallel with the Machinery Hall, the total length being 276 feet. From this, three 6-inch mains were taken to supply the engines, together making 383 feet in length. Besides these three engine mains, numerous smaller pipes for the different machines took their supply from the 10-inch main.

Three condensed water traps were placed in connexion with the steam mains; these were of Austrian manufacture, and were constructed on the float principle, but were found not to be certain in their action, as, whenever steam was let into the pipes it was necessary to use great caution, as owing to the length and thinness of the pipes the amount of condensed water that accumulated was something considerable. Care had to be used at all times, as more condensed water accumulated than the traps could carry away, or could pass the cylinders of the different engines. The whole of the steam pipes, with the exception of those in the boiler-house and the coupling-up pieces to the engines, were supplied and

fixed at the cost of the Austrian authorities, but had to be maintained by the British Commission.

The Austrian General Direction also undertook to pay the wages of the engineers and stokers employed, but it was not found possible to get competent men at the scale of wages allowed, viz., engineers, 4 gulden or 7*s.* 8*d.* per day; stokers, 3 gulden or 5*s.* 9*d.* per day; and labourers, 2 gulden or 3*s.* 10*d.* per day; so that the British Commission was obliged to pay the difference, engineers receiving 5*l.* per week, stokers 3*l.* 10*s.* per week, and native labourers 3 gulden or 5*s.* 9*d.* per day.

Three steam cranes were lent to the British Commission —on the same conditions as the engines—for the purpose of unloading and loading the exhibits.

One 5-ton crane by Messrs. Appleby Brothers, Emersen Street, Southwark; one 3-ton by Messrs. Charles Powis & Co., Millwall Pier; these two cranes were constructed to travel on an ordinary line of rails, and to lift from or into a railway waggon. They were both used entirely in the Machinery Hall, where two lines of rails were laid down so that a railway waggon could be brought in close to where it was wanted to be loaded or discharged.

The third crane was lent by Messrs. Aveling & Porter, Rochester, and was constructed to lift two tons, and to travel on an ordinary road; it could also be used as a traction engine, or a stationary engine to drive a saw bench, &c. This firm also placed an 8-horse-power traction engine and two road waggons at the disposal of Her Majesty's Commissioners, and these, in conjunction with a 6-horse-power traction engine and four trucks, lent by Messrs. J. Fowler & Co., Leeds, were found to be very useful for bringing back the empty cases at the close of the Exhibition.

Messrs. Appleby Brothers also placed at the disposal of the Austrian General Direction, two steam cranes, one to lift seven tons, the other to lift three tons; and Messrs. Aveling and Porter contributed a 3-ton steam road roller.

DR. RUSSELL.

SMALL ARMS.

Report on Small Arms, &c., by W. H. Russell, Esq., LL.D.

Sir,

As juror appointed to act for the British Commission, in Section 3, Group VII., I venture to submit the following special report, not that I dissent generally from the awards made by the jury, but that I desire to point out certain defects in the composition of the jury, which necessarily affected the manner in which prizes were allotted, and at the same time to indicate what appear to me to have been defects affecting their own interests on the part of the exhibitors.

Formation of jury.

The jury on Group VII. was constituted on the 16th of June, under the presidence of M. Guillaume D'Allemagne, of the Sclessin Ironworks, Belgium; a very effective President and able man of business, but ignorant of any language except his native tongue, and therefore indebted to interpreters for what he knew concerning the operations of the jury. The English vice-president, his Grace the Duke of Manchester, did not attend, but Freiherr von Wertheim, the well-known Safe manufacturer, was indefatigable in attendance, and persistent in the part he took in the business of the jury.

The objects under the head of "Metal Industry," the appreciation of which was referred to the jurors in Group VII., consisted of goldsmiths' and silversmiths' work, jewellery, iron and steel wares, excluding objects especially mentioned, manufactures of other metals and their alloys, weapons of every description except military arms, processes and inventions in these manufactures, and statistics of production. It was resolved to divide these objects into four separate classes, for each of which a Section of the jury was subsequently formed; the jury on the Group being thus split into four sections, the first of which was for goldsmiths' work and jewellery, the second for iron and steel ware, the third for weapons not of war, and for swords, revolvers, &c., and the fourth for the processes and inventions and statistics of productions. These sections were formed on the following principle. Each juror was asked to what section he desired to belong, and decided for himself to what he would apply himself. It may be said that the jurors for the Groups were constituted in a similar manner, but that is not alto-

Jurors allotted to sections.

gether the case. It is true that those who accepted the honourable position of jurors at the desire of His Royal Highness the Prince of Wales, as President of the Commission, might have perhaps excused themselves, but once they had accepted the mission, the Royal Commission, regulated by the exigencies of the work, controlled their freedom of action, or more properly speaking did not allow a free selection by the jurors of the groups for which they considered themselves more especially fitted. The field from which they were chosen was limited, and many of my brother jurors will admit that they were told off to departments which were not always those they would have selected of their own free will. Without adverting to the composition of juries in other sections, I shall state what occurred in my own. Personally I should have preferred to have acted in groups the subjects and exhibits contained in which I considered myself better qualified to adjudicate upon, but there were already adequate representatives of Great Britain acting on these. When Group VII. was divided into Sections, I selected the third. The members of that Section were Mr. Werndl, manufacturer of arms, &c., Steyer, Austria; Mr. Gastinne-Renette, gun-maker, Paris; Mr. Neff, sword manufacturer, Solingen, Prussia; Mr. Painter, the United States; Captain Vitaliano, Royal Italian Navy; Mr. Giaccometti, of the Turkish Embassy, representing Turkey; and Mr. Zuloaga, representing Spain. Colonel La Charette was named as expert on behalf of the Belgian government, but he did not attend. The Section elected Mr. Werndl, President, Mr. Renette, Vice-President, and Mr. Neff, Reporter. Among these members there was but one person acquainted with the use of arms for the chase, and but one who was competent to give an opinion on the merits of "armes blanches." Mr. Werndl, an experienced gun-smith, had no knowledge of the use of fowling-pieces, nor had Mr. Renette any practical experience of the arms of which he is an accomplished manufacturer. There was no standard according to which the judges regulated their decisions, and nothing but a sincere desire to do justice to the exhibitors was the common attribute of all the jurors. On the second day after the Section was constituted our labours commenced, by a visit to the Exhibition, for which purpose we assembled at 8 o'clock a.m. A very intelligent young gentleman of Mr. Werndl's establishment, who had previously made a careful survey of all the exhibits, attended to conduct the jurors to the stalls, but on the first day as on the last, the greatest difficulty was encountered by the members of the section in

Members of Section 3rd, Group VII.

Want of practical knowledge amongst the jurors.

consequence of the absence of representatives of the exhibitors, or by the presence of representatives who knew nothing whatever of the arms, except the prices. This impediment, pretty generally encountered in all, was by no means least formidable in the British department. Much time was wasted in returning to cases which had to be passed over day after day owing to the absence of any means of examining the contents. Another difficulty was presented by the topical arrangements at the Exhibition, which showed very unfavourably in this respect when compared with that of Paris. It was almost impossible to come to any satisfactory arrangements to secure the attendance of those in charge of the cases. It can easily be conceived how difficult it was to keep an appointment even within an hour, when accidental detention, protracted examinations of particular objects, and the eagerness of each juror to secure the exclusive attention of his companions for the work of his own country were continually to be encountered. The jurors were obliged to traverse long corridors and passages from the exhibits of one country to those of the other, and oftentimes on arriving at a particular department, they found the cases locked and the place deserted. Scarcely any of the catalogues were ready for use, and those which were ready, with the exception of the British catalogue, to which, however, additions had to be made, were not perfect. It was impossible to determine precisely the periods in which the official inspections of any particular country would begin, except that with which the labours of the day commenced. A detailed examination or a protracted discussion led to delays, which retarded the arrival of the jurors after the hour named, till the exhibitors or their representatives tired of waiting went off. The habits of individual jurors tended to interfere with the dispatch of business. One wanted to breakfast at mid-day, another felt it necessary to dine at 2 o'clock. At hours when some members were full of energy and desire to work, others considered it only natural to retire for the day altogether. But on the whole, it may be said that there was the greatest desire to work harmoniously in the common object of adjudicating justly and promptly. The failure of one exhibitor to keep an appointment sometimes frustrated the efforts of the jurors, and caused great disappointment to exhibitors elsewhere. For instance, if the English department was warned that the Jury on small arms would be round at 10 o'clock a.m., and the American department that they would be round at noon, a detention in Germany, with several hundred yards in intricate passages, crowded with people, to

Waste of time.

Want of catalogues.

Sundry causes of delay.

work through afterwards, would prevent the jurors arriving at the time indicated, and they probably found when they got there that the gentlemen had gone off. The plan of the building is so familiar that I shall not dwell further upon obstacles of that nature which it necessarily presented.

Before proceeding to details I may remark, that having seen the arms at the recent exhibitions in Paris and elsewhere, there does not appear to me to have been any solid or substantial improvement in the work at this Exhibition; but certainly, if I may venture upon the expression of my own opinion, I should say that in Vienna and in Paris they are running the London makers very hard indeed in excellence of finish and quality as far as the eye can judge, regard being had to the prices, which I hold to be a very important consideration in determining the prizes to be adjudicated in an exhibition of this kind.

Vienna and Paris *versus* London.

The Frenchman and the Austrian regard fowling pieces as works *apart* upon which taste in ornamentation must be expended; whereas the Englishman and the American look upon a fowling piece as an article with which to kill game, the excellence of which is in the soundness, finish, weight, general handiness, and solidity of the weapon. In fact the last gun an ordinary English sportsman would select for grouse or partridge, would be one of the beautiful productions of Renette or Lepage, or the exquisitely finished fowling pieces of some Austrian makers. The most delicately ornamented locks and stocks exhibited were, however, apparently old acquaintances, mere show pieces, intended to demonstrate how much grace, ingenuity, and exquisite workmanship could be lavished upon iron. In one of Mr. Renette's guns the metal work of the stock was cut into beautiful designs of animals, birds, and beasts, and tangled boughs; the "cock," representing a stoat with a bird in its mouth, mounting the branch of a tree. Lepage's case contained specimens of exquisite beauty of workmanship. The peculiar merits represented by solidity, and strength, and a plainness approaching to ugliness, were conspicuous in American work. But in the United States cases there was no weapon which could be called a fowling-piece; and even the pistols, for which the American armourers have obtained such reputation, were military, and intended for cavalry and infantry, or perhaps to settle small individual differences which could not be properly assigned to sporting. The disappointment experienced at the aspect of the British department was only to be alleviated by an examination of the work of some very few exhibitors. There was no novelty or any very

Points of difference between Continental and English and American fowling-pieces.

American arms.

English arms.

marked improvement to arrest the attention of the jurors, for whatever might be the excellence of Mr. Henry's self-cocking action and side lock, it was scarcely subject to the judgment of this particular section, and grave doubts were thrown upon the safety of Mr. Murcott's system, by the failure of the gentleman who explained the action of it to the jurors. It was a surprise to find some of the foreign jurors well acquainted with the names of manufacturers and gun makers who are but little known at home. The case of Messrs. Webley and Son, of Birmingham, attracted particular attention by the excellent workmanship, finish, and number of the arms exhibited. It was scarcely surprising to learn these guns were not unfrequently marked with names belonging to makers of the highest reputation, and sold at double the price charged by Messrs. Webley. The closest examination could not detect any substantial difference between specimens of their highest priced double gun, and that which would be furnished at a much larger cost by London makers whose names need not be mentioned here.

The business avocations of the excellent President of our section compelled him on several occasions to leave Vienna, but with these drawbacks the labours of the jury were pursued with the utmost zeal and assiduity, although the full number was seldom present. The chief impediment to continuous work lay however in the division of duty entailed upon the members of the Section who had also elected to work in Sections I., II., or IV. Therein there seemed to be a radical inconvenience, for just as we were engaged in an interesting examination, a member would pull out his watch and say, "I am obliged to go to Section — immediately," and then we had to adjourn till next day. On the 2nd of July Mr. Neff was summoned to Germany, and, as we had by that time completed our general view and in most instances the detailed examination, of the arms, I went to Karlsbad. Mr. Gastinne-Renette, assisted by Captain Vitaliano, and Mr. Werndl undertook to complete the appreciation and obtain the information which would enable us to come to a final decision as to the merits of the various exhibitors in the absence of the other jurors, the understanding being that I was to be informed of their return. I left Karlsbad and arrived at Vienna on 16th July after the receipt of the communication that Mr. Neff had come back from Solingen, and on my return the Group sittings had re-commenced, and the members were engaged in the discussion and consideration of the lists furnished by the Presidents of Sections. It was with some surprise I learned that in the absence of Mr.

Another impediment to continuous work.

Neff and myself M. Renette had prepared a list which he said had been agreed upon by Mr. Werndl and himself, subject however to our approval. For an inspection of this list I applied on three separate occasions, in vain, though M. Renette promised that he would furnish me with a copy. I attended each day, our Section being now deprived of its president, who was again absent on business. Mr. Gastinne-Renette did not up to the moment of his handing the list to the President of the Group give me a copy of it, or allow the document to leave his possession. When it came to the turn of Section III. to report the result of its labours, Mr. Gastinne-Renette told me he intended to propose that Diplomas of Honour should be awarded to "the town of Solingen," to the "city of Paris," and to the "city of London." I objected to a Diploma being awarded to the City of London. The members of the Section present were requested to withdraw to discuss the matter. Mr. Neff was willing that Solingen should receive a Diploma of Honour, but he indicated unmistakeably his opinion that the ground on which the Diploma should be awarded to Solingen were not applicable to London or to Paris. All the "armes blanches" submitted to the Section, with insignificant exceptions, by German, Austrian or Bavarian manufacturers were discovered to have Solingen blades, and therefore it was fair to suppose they were the best blades of which the various exhibitors could avail themselves. The award of a Diploma to "the city of London" could not be maintained on such grounds. The London makers procure their barrels from Birmingham as the Paris makers take theirs from St. Etienne, or the Austrian makers from Liége. When I asked who was to hold the Diploma of Honour if it were awarded to the "city of London," Mr. Renette replied, "the Lord Mayor," and did not seem to think I was serious in disputing his lordship's right to accept the trust, far less to heed the statement that the London exhibitors did not live in the city of London, and that the "city" had nothing to do with them.

Question of diplomas of honour to Solingen, Paris, and London.

Mr. Lancaster was admittedly the exhibitor of the best fowling-pieces. Mr. Werndl and all the jurors agreed on that point, and all that M. Renette could urge was that "the Mr. "Lancaster in question was not the celebrated maker of "that name." I pointed out that to include Henry of Edinburgh and the Birmingham makers in a Diploma to "the City of London," which did not manufacture fowling-pieces at all, was unfair and illogical. Captain Vitaliano appeared to feel the force of my objections, and told me

privately that he agreed with me. M. Renette, however, was resolved that Paris should have a Diploma of Honour, *quoad* Paris. The firm of Gastinne-Renette were "*hors concours*," Lefaucheux was "*hors concours*," and M. Renette probably (I say this with all reserve) did not feel disposed to incur the odium and the responsibility of awarding a Diploma of Honour to any one gun-maker in Paris, and only one could be awarded. I need not observe that the Group Jury awarded the Diploma of Honour. It is almost the rule to accept the decisions of the Sections respecting awards without cavil. Had I dissented from the proposal of M. Renette, I should have placed myself in a position in which I should certainly have encountered defeat. M. Renette could have stated that Mr. Werndl, the President of the Section, and a proficient in the manufacture of arms, and he, the Vice-President, thought that London should have a Diploma of Honour, whilst I stood out for giving it to a single maker. Undoubtedly, on a vote of the Group Jury, I should have been out-numbered by 30 to 3, as they would have supported the views of the majority of the Section. M. Renette accordingly handed in the recommendation as to the three Diplomas of Honour, which was received by the President of the Group, and attention was at once called to the fact that the award was contrary to the rule which laid down that there should be no honours or prizes awarded to the exhibitions of corporate bodies. The Delegate observed that he doubted whether the Council of Presidents would receive the award at all. M. Renette, subject to the chance of the rejection of all our own awards, adhered to his proposal. At a subsequent meeting of the jury M. Renette handed in the list of awards of Medals and of Honourable Mentions, of which I had in vain endeavoured to procure a copy or even perusal, and as I sat behind him I saw with astonishment the names of persons who certainly had not deserved distinctions, which scarcely could be called honourable when they were allotted to all exhibitors, the differences between whom was regulated by some rule difficult to understand, according to which one received a Medal of Merit, another that of Progress, and another only Honourable Mention. I think the justice of these appropriations subjected to criticism would sustain the objections I made to awarding the same prizes to exhibitions of most unequal merit. In fact in Sect. III. Gr. VII., every exhibitor had some prize. It is needless to observe that the possession of a prize under such circumstances is no indication of merit, unless the act of exhibiting is considered in itself meritorious. With these re-

Promiscuous distribution of prizes.

marks, which are made because I desire to set forth the reasons why I dissented from some of the conclusions of the jury, I beg leave to submit respectfully to Her Majesty's Commissioners the following notes on the exhibits which we examined, and my view of the rewards to which they are entitled.

First. I think it may be premised that none of the exhibitors present any useful, novel, or ingenious invention to distinguish this exhibition from the last at Paris.

Secondly. That the exhibition was deficient in quantity and quality. Some countries, such as Russia, were barely represented. Belgium was only represented by one firm. Two of the best known firms of Paris were *hors concours*. The English exhibitors were very few. The Americans sent no fowling-pieces, and their makers exhibited merely pistols and military rifles, and with the exception of makers from Berlin, Prague and Vienna, there were few manufacturers of arms whose workmanship was even of second class excellence in the foreign department.

Great Britain.

The arms exhibited by the English manufacturers were not numerous, nor did those who are considered among the best makers, and who command the highest prices, think it worth their while to send specimens to the Vienna Exhibition. The makers who sent specimens were, however, fair examples of workers in the highest class of arms, as well as in those which are remarkable for moderation in price.

Proposed Diploma of Honour to Mr. Lancaster.

First among those who exhibited sporting arms of the highest class may be placed Mr. Lancaster, of South Audley Street, to whom I proposed to give the Diploma of Honour, and who would certainly have received it, but for the difficulties which arose in connexion with the decision of Mr. Gastinne-Renette to award this high distinction to "cities," in direct opposition to the rules established by the Central Administration. Mr. Lancaster's exhibits consisted of breech-loading central-fire guns and rifles on two different systems, one that of locking or closing the barrel by what is termed the double grip, the other snap or self-closing, with a lever to open the barrels, placed according to the wish of the person using the weapon. They all had patent rebound and half-cocking locks, differing only from the ordinary form of lock by the elongation of one arm of the mainspring, which, on the hammer descending and striking, catches the tum-

bler, and brings it back into a safety or half bent. In one specimen the introduction of what Mr. Lancaster calls his patent jointed direct action striker was noticed. It may be observed that the foreign jurors did not seem to be favourable to the rebounding or half-cocking system. Mr. Lancaster considers, however, that his patent lock is an important improvement in central-fire breech-loaders; that the hammer must always rest in the safety bent, and the gun can never be fired from the accidental slipping of the hammer, but only by pressure on the trigger when at full cock as the sportsman is about to fire. The rifles were ·450 bore, firing the bullet now in use for sporting and express rifles, hollow in the apex, with wax, wood, or copper inserted; the charge something under four drachms of powder, the trajectory being flat so that the same sight answers for all distances up to 200 yards. Mr. Werndl detected a flaw in the rifling of one of the barrels, which was pointed out to the other jurors. A pair of double guns stocked with rhinoceros horn, very chastely finished, attracted the attention of the Emperor. (Progress medal.)

Improvement in central-fire breech-loaders.

Next to Mr. Lancaster came Mr. Alexander Henry, of St. Andrew's Street, Edinburgh. His exhibits consisted of a double central-fire breech-loading express rifle, ·450 gauge, with a Lefaucheux back action, rifled upon Mr. Henry's own patent; a single breech-loading express rifle, the same gauge, with Henry's patent block action and rifling; a single miniature breech-loading express rifle ·360 gauge, with the same action and rifling; a double central-fire fowling-piece, ·12 gauge, double grip, snap action, top lever. The jurors were unanimous in expressing a high opinion of the finish of these arms, but, although there was no reason to doubt it, there was no opportunity of ascertaining whether the merit claimed for the system of rifling would exhibit itself on trial. The hollow conical ball, weighing 270 grains, with four drachms of powder from the ·450 gauge rifle, is point-blank over 150 yards with the standard sight; and the miniature express charge and bullet of the same weight, shoots without requiring elevation, up to the same distance. The jurors were prohibited from examining military arms with a view to report upon them, but could not refrain from expressing their high opinion of the general excellence of these arms. That opinion was the more valuable from the position of Mr. Werndl, the President, who is a most experienced practical armourer, and who has invented the weapon with which the whole of the Austrian infantry are armed. Mr. Henry was

Mr. Henry of Edinburgh.

Merits of his Arms.

certainly entitled to the highest Medal had it been our province to award one.

Mr. J. D. Dougall, of St. James's Street.

Mr. James Dalziel Dougall, of St. James's Street, exhibited a case of arms with patent appliances, but unfortunately there was some difficulty in obtaining information, owing to the difficulty of finding his representative in attendance; but the well-known excellence of his manufacture, combined with the moderation of his prices, secured for his arms the appreciation of the jurors. Considered in reference to the prices furnished to the jurors, these arms were of remarkable merit, and in finish left little to be desired. The jury, under the circumstances, did not feel justified in awarding to Mr. Dougall more than Honourable Mention, although it is only fair to mention that the Gold Medal was awarded to him at Moscow in 1872, and that he received medals at the Exhibitions of Paris and London. There were six guns exhibited by him. One a 12-bore tiger rifle, firing a conical explosive shell self-igniting; a ·450 double express rifle for deer-stalking, &c.; an 8-bore double-barrelled shoulder gun, weighing 12 lbs., for a charge of seven drachms of powder, for swans, geese, &c.; and a 12-bore central-fire fowling-piece, all on what Mr. Dougall calls his patent lock-fast principle. The fifth was a combination of the patent lock-fast and the self-closing lever fowling-piece; and the sixth was a self-closing 12-bore for ordinary sporting purposes.

I have already mentioned Mr. Murcott's arms. When the jury came to examine them, an officer who had been requested to explain the advantages of the lock, &c. made some mistake, by which it came to pass that when the gun ought to have been safe it was loaded and on full cock, and this circumstance increased the force of the arguments against a concealed action of doghead, &c., which previously weighed with the foreign jurors, and caused them to form an unfavourable opinion of Mr. Murcott's exhibits.

Messrs. Webley, of Birmingham, appeared to me fully entitled to a medal of the highest class for their exhibits, of which mention was made in page 5, and their case, which displayed many varieties of small arms, revolvers, &c., was deserving of high commendation. It was impossible to obtain any access to the case of cutlery, &c., in which Messrs. Schletter, of Birmingham, had placed a couple of fowling pieces.

As to swords and daggers, of which there were numerous exhibits from France, Spain, Italy, Germany, Russia, Austria, &c., and some from Great Britain, I can express

no opinion, for there was only one member of our section who had any accurate knowledge of their merit, and that was Mr. Neff, of Solingen, himself a famous manufacturer. According to his judgment our awards were made, and no matter what the country was which we were examining, Mr. Neff found almost invariably that the blades mounted in Vienna, Prague, &c. came from Solingen, whence it seems the British cavalry are mainly provided with sword blades also. Señor Zuloaga exhibited some beautifully chiselled work, and there were Russian blades and Toledo blades of high excellence, but the awards assigned by the jury may generally be taken as a fair measure of their respective merits.

Italy.

There were five exhibitors.

Luigi Moletto, Barri, near Padua.

No. 1. Luigi Moletto, of Barri, near Padua, exhibited a curious repeating rifle, in which a tube underneath the barrel under the pressure of a strong spiral, ejected its contents one after the other into the breech-loading apparatus which was of an ordinary character. This lower barrel contained twelve charges, and when it was full the weapon was ill balanced, heavy, and clumsy. It could be only looked upon as a dangerous and ugly toy, the principle on which the charges were driven into the rifle barrel being simply that applied to children's tin guns. When the jury were examining it, the man in charge handed a dummy cartridge to one of them to prove the action of the breech-loading apparatus, but as it seemed uncommonly heavy, the juror opened it before pulling the trigger, and discovered that it was capped and fully charged with powder and ball.

Awkward mistake.

Attilio Roberto, of Mantua.

No. 2. Attilio Roberto, of Mantua, fairly finished fowling-pieces, for pin cartridges; barrels light; price 400 francs. (Honourable Mention.)

Toni e figlio, Rome.

No. 3. Toni e figlio, Rome, fowling-pieces on what they call a double system, which does not seem to present any remarkable advantages, the object being to adapt the gun as a muzzle-loader in case cartridges fail. (Honourable Mention.)

Izzo, of Naples.

No. 4. Izzo, of Naples. The guns of this maker stand first amongst the Italian exhibits, which are, however, not of remarkable excellence. One fowling-piece had a special trigger guard, which appeared liable to serious objection. The guard opens in the middle and acts as a lever by which

the barrels are turned vertically downwards, and the breech thus presented to receive the cartridges, but it would be likely to injure the fingers. The barrels of this maker are far superior to the locks, and the light, well-balanced, and elegant double guns, price 1,000 francs or 40*l.*, perhaps represent the highest degree of Italian excellence in this branch of work. (Medal of Merit.)

Micheloni, of Milan.

No. 5. Micheloni, of Milan, exhibited a case of double guns of ordinary quality at moderate prices. (Honourable Mention.)

Belgium.

Bayet Frères, of Liége.

The famous workshops of Belgium were represented solely by a large case of Messrs. Bayet Frères, of Liége, containing a great number of fowling-pieces, guns, and pistols, on different systems, all the principal makers of France and England being represented by name. The feature of the exhibits, however, to which the attention of the jurors

Low price.

was especially directed, was the price at which these arms were produced. As a specimen of the best work of the firm, a breech-loading fowling-piece was produced by the agent. The lockplate, guards, &c., were highly decorated and artistically engraved, the stock carved and handsomely chased, the barrels well finished, and the balance good, but there were no means of unscrewing the locks and examining them. The price of this fowling-piece was 975 francs or 37*l.* Several of the fowling-pieces handed to us for inspection, as specimens of cheap and excellent arms, were decidedly dangerous, as some, when the left-hand trigger was subjected to a steady equable pressure, went off at half-cock. The price of these guns was from 9*l.* to 12*l.* A rifle which looked solid and well made, with excellent rifling, 8*l.* Amongst the curiosities of the Messrs. Bayet, were pistols—a pair of double-barrel pistols, with bullet mould, price 4*s.* We were informed that these barrels were all subjected to proof the same as that used in England.

One Lefaucheux revolver with an ebony stock, cutting relief on gold, price 150 frs., would appear worthy of honourable mention. A double-barrelled fowling-piece, central fire with rebounding cocks and safety action, for 300 fr. or 12*l.*, was exhibited to the jury as worthy of commendation, and it certainly was superior to any fowling-piece which an English maker could produce at the same price. A double-barrelled Lancaster fowling-piece of the same system for 8*l.* had the inconvenience of going off at half-

cock when the trigger was pulled. To MM. Bayet I should have awarded at most, "Honourable Mention" on the score of exceeding moderation of prize. They were the sole exhibitors of arms in the Belgian court. (Progress medal.)

Fonson et fils of Brussels exhibited sabres, daggers, &c., but the blades were made at Klingenthal and Solingen. Fonson et fils of Brussels.

Spain.

If one were to judge, from the exhibition of weapons in the Spanish department, of the present state of arms manufacture, Spain would appear to be far behind-hand in every*thing* but the excellence of sword-blades, and the good quality of the iron in the gun barrels. The principle adopted is that which was in vogue in England at the time of the introduction of the percussion system: viz., the use of a hollow pin filled with percussion powder to ignite the charge when struck by the doghead. The inlaying of barrels and locks was generally elegant, and the ornamentation of the swords exceedingly rich. Quality of iron.

Theodoro Barzabal exhibited very highly finished double and single guns and revolvers. All are very old systems and seem apparently made many years ago. (Honourable Mention.) Theodoro Barzabal.

United States.

The exhibitors from the United States, although they wished to subject their cases to the judgment of this jury, came more properly under the consideration of the jury which dealt with arms of war. They were—

Mr. Remington.
Mr. Sharp.
Messrs. Smith and Wesson.
Mr. Colt.

Remington
Sharp,
Smith and
Wesson,
Colt.

The merits of Remington's system are well-known, but I should not have mentioned his exhibits here, had it not been necessary to call attention to his single-barrelled rifles adapted for sporting purposes, in which, by recent improvements, a direct action is obtained in the lock apparatus and the pin is withdrawn by the action of loading and is no longer liable to damage by rust. These weapons, and also revolvers on his principle were well finished and cheap. (Honourable Mention.) Recent improvements in lock apparatus.

Sharp has introduced no improvement in his well-known arm. The rifles he exhibited were very heavy and not as well finished as those of Remington, but his system is essen-

tially safe, and it is impossible to discharge the rifle till the loading movement has been completed.

Smith and Wesson's arms could not be examined by the jury as they were attached to the shield on which they were exhibited, but those which could be taken down seemed well finished though the locks were not all equal in that respect, and the back-sights on the rifles were placed badly and would apparently interfere with the loading of the arm.

AUSTRIA.

The general impression produced upon the jury by the exhibit of Austrian manufactures was certainly favourable. Several makers of high reputation produced arms which aimed at combining the simple and solid excellence of English work, with French taste and decoration; but it was observed that these makers charged prices fully equal to those of first class French and English makers. There is a special locality where a race of arm-makers produce large quantities of fowling-pieces and pistols, at prices to suit all classes. In some Styrian valleys this industry has been pursued for centuries, generation after generation, very much as in the vicinity of Sheffield, where for long series of years the people have been devoted to the manufacture of steel ware and cutlery. Carinthia is the head-quarters of this industry; and in one case there were the works of 62 exhibitors from one district. This was styled the "Collectiv Ausstellung der "Waffen Fabrications Genossenschaft."

Styrian factories.

The arm-makers of Vienna are numerous, but in my judgment, none of them, not even Mann, who seems to me in some respects better than Springer, come up to Lebeda of Prague. In his case was a double-barrelled breech-loader, elegantly mounted, with stock carved and finished throughout in the highest style of workmanship. The barrels were apparently of the very best material and make, and commanded especial praise, and I would have recommended it for the Diploma of Honour. The price however was 130*l.*

Lebeda of Prague.

Wenzel Maschek, of Vienna, exhibited arms of a superior quality, barrels exceedingly well finished, and stocks well fitted, but the locks not so good as they might be. The average weight of the fowling-pieces seemed to be about 7 lb.; and for 460 francs a handsome double gun, in case, with an extra barrel, rifled,—locks, barrels and stocks all of a very fair description could be had. (Medal of Progress.)

Wenzel Maschek.

Kirner, of Pesth, Hungary—arms well balanced and finished, and style of workmanship generally superior. The

Kirner, of Pesth, gun [illegible]rels.

barrels of his guns, and indeed, those of all the Vienna makers, come from Liége, just as the barrels of our London makers come from Birmingham, and those of the Paris makers from St. Etienne. (Medal of Merit.)

Johann Ahrr, Marburg. This maker had a case of fowling-pieces and sporting rifles, remarkable for finish, good workmanship, and cheapness. A Lancaster double-barrelled rifle, 220 florins or 22*l.* A single barrel Werndl rifle, 160 florins. A Lafaucheux, scarcely to be distinguished from the best specimens of that maker, 20*l.*—the barrels from Liége finished at Marburg, and locks made altogether in that town in his own workshops. (Medal of Progress.) Johann Ahrr, Marburg.

The case of the well known maker Johann Springer, of Vienna, contained a large number of rifles, fowling-pieces, and revolvers. His best rifle, an express, warranted point-blank up to 200 schritt, charge 100 grammes of powder, and ¾ths of a loth of ball, price 40*l.*, seemed a perfectly sound and trustworthy weapon, the interior rifling leaving nothing to be desired. (Medal of Merit.) Johann Springer, Vienna.

Most of the Vienna makers turn out arms in which the locks do not equal in merit the other parts. This was also the case with Johann Nowatny of Prague, who deserves praise for the decoration and finish of his arms. The case, containing a double-barrelled gun, with one pair of barrels rifled and the other smooth, price 650 florins, seemed to be of superior merit; whilst the fowling-piece of which the price was 55*l.*, was certainly provided with locks of very inferior quality. (Honourable Mention.) Quality of locks, Johann Nowatny, Prague.

Franz Reitzner, of Neudeck, and Franz Leitner, of Ischl seemed mainly to aim at producing rifles of moderate price; Gasser, of Vienna, who has a large manufactory at St. Polten, excelled in the production of arms in which cheapness was combined with considerable excellence of workmanship. (Honourable Mention.) Franz Reitzner, of Neudeck, and Franz Leithner, of Isehl.

He furnishes revolvers, well finished, for the army, at 17 florins, and a double barrelled Lancaster, well balanced, and furnished with excellent locks and barrels, with which no fault could be found, and material finished, is offered for 350 florins or 35*l.* But when we come to the productions from Ferlach, already alluded to, it must be said that cheapness is dearly bought, and that such fowling-pieces as we saw—a double-barrelled muzzle-loader, for example, for 10 florins, or double-barrelled breach-loader for 100 florins,—would be much more dangerous to those who used them than to the objects at which they were presented. Over cheapness.

The Sanitary Pavilion.

It is to be regretted that the Government did not accede to the request of the Commissioners to send out a competent reporter to examine the very remarkable exhibition connected with sanitary science, transport in war, field hospitals, ambulance arrangements, and, above all, the train by Baron Mundy, made in Paris, and forwarded by rail to the Exhibition, as well as the military hospital carriages of the Continental Powers, which were to be seen in the Sanitary Pavilion.

Baron Mundy's ambulance train.

Although the Exhibition was not as complete as it would have been had a special programme been forwarded to the various Governments a little earlier, there was much of a most interesting, and suggestive character; and the report of such an authority as Professor Longmore upon this portion of it would have been most valuable.

The idea of having objects connected with this department collected in one Pavilion was not realised. Some were in the machinery halls, and others scattered about in the beautiful labyrinth of the palace itself. The Continental societies for the aid of sick and wounded in war, however, made a fair show, but there seemed to have been no interest taken in the Exhibition in England, and certainly the representation of that active charity, which was so conspicuous during the last great war was of the most meagre character.

The War Office.

The War Offices it may generally be said, did not enter with very much heart into the display of their sanitary systems, and as a Vienna writer remarked, they seemed much more inclined to show the world the means they had of killing than those of curing; but the Emperor of Austria and the Archdukes took a very active part in developing, as far as possible, what may be called the humanitarian part of military science. The Sanitary Pavilion stood apart and invited inspection, which it well deserved. The expense of its construction was borne by the various societies connected with the Geneva Conference for the aid of the sick and wounded in time of war. Of these the Teutonic Knighthood, the Patriotic Women's Association of Austria, the Société de Secours aux Blessés of France, aided by the houses of Locati of Turin, and Liposskay of Heidelberg, may be named as the principal. The objects exhibited related almost exclusively to military transport and to ambulance work in time of war. Without attempting a special classification of the exhibitors it may be said that the principal and most interesting object was the French sanitary train already

Societies connected with Geneva conference.

referred to, constructed at the *atélier* of M. Bonnefond, Ivry sur Seine, under the eye and on the plan of Baron Mundy, at the cost of the Société de Secours aux Blessés. The ingenuity shown in the construction of this train was only equalled by the excellence of the workmanship, and the thought bestowed upon every detail was evidently the application of practical lessons learned by the personal experience of more than one rude compaign. Having regard to the great number of travelling accidents which had recently occurred in England, there was some force in the earnest insistence of Baron Mundy, that to all English trains, travelling at high rates of speed, some of his hospital waggons should be attached, and that at all large towns a complete train should be kept in readiness for despatch to the scenes of collision or accident.

Société de Secours aux Blessés.

Hospital waggons to be attached to all English trains.

On entering the Sanitary Pavilion the eight waggons, drawn up on the line as if ready to start, caught the eye at once. One of these waggons is fitted up for the medical officers, one for cooking, one for provisions, one for hospital stores, &c., and four for the transport of the sick and wounded. The doctor's carriage is a marvel of ingenuity. It is divided into compartments for four medical officers, each with an armchair, which forms a comfortable bed at night, a washing stand, reading lamp, closet for clothes, writing desk, chair, clock, with barometer and thermometer. The waggon is warmed by a stove, and a water reservoir provides the necessary supply where it is required. Each of the inmates of this moving house can retire to his own chamber and be still whenever he pleases, and there is every convenience within the limits of the waggon, so that he need not leave it for a moment. This is a marked improvement upon the old sanitary waggon, or rather on that which was provided and attached to military trains by other Governments wherein all the medical officers have to sit in one compartment without any means of retiring. Although the waggons appear, when fitted up to be quite unlike anything formerly seen, they are but simple railway vans transformed by ingenious applications, and provided with the most admirable means of ventilation, as well as of protection against dust and rain. The manner in which access is secured from one waggon to the other, so that the doctor can pass with ease from end to end, is peculiarly worthy of remark. In each of the transport waggons 10 men are carried, 6 on one side and 4 on the other, and where the space gained by the omission of two beds is utilised for the stove and water-closet, the latter is placed outside, and separated from the interior of the waggon, but with easy access.

Description of waggons.

Improvement on old sanitary waggons.

Access from end to end.

Slung litters objectionable.

Litter or common bedsteads, can be placed in the carriage. Slung litters are objectionable, as even at the lowest speed railway trains must oscillate, and the sick and wounded are then exposed to great suffering. In each waggon all materials and implements required for sanitary purposes are stored, and the fitting can be removed. The waggon in peace time becomes an ordinary van for the transport of goods, whilst in war it will carry troops or provisions to the front, and can be fitted up in a very short space of time as an ambulance to return with sick and wounded from the field of battle. The litters, or beds are elevated above the floor, so that the vans can be cleaned daily without moving the occupants, and the surgeon can attend also with greater ease. It is possible to put 15 into a waggon in case of need. The kitchen of the waggon would need a report to itself. All the apparatus is of a most admirable and ingenious construction, from the water cistern containing 1,800 litres of water down to the tiny saucepan with its closed cover, so that the contents cannot be spilt even in the most violent oscillation. The operations of the cook can be conducted with as much ease and comfort as in the best appointed kitchen in the house of a nobleman. Although Baron Mundy's sanguine expectation that the English legislature will order an establishment of his trains to be kept by the great Railway Companies is not likely to be realised, he deserves the thanks of all those interested in alleviating the miseries of war, for his admirable exhibition.

Beds elevated above floor.

German system.

When we come to compare this sanitary train with others which have been forwarded for the purpose of exhibition, we cannot but see, however, that the rough, practical, and uncomfortable German system is more adapted for the exigencies of war, especially upon a large scale, when the resources of a State in rolling stock are heavily taxed. In the sanitary train of the Palatinate the ordinary railway vans are adapted for hospital purposes, but one is immediately struck by the difficulty which would be experienced in lifting a wounded man into one of these carriages, which is high above the ground and unprovided with steps, whilst the footboard is too narrow to permit of a ladder being elevated to it. Baron Mundy's thoughtfulness has provided for this difficulty by an arrangement whereby the iron uprights at the ends of the waggon can be removed and the broad steps coming down nearly to the ground will readily permit the litter, or the sufferer to be borne to his place inside. In the Palatinate waggon, however, there is an ingenious invention by which the motion of the carriage is regulated

Invention to regulate motion according to weight.

according to the weight inside it. The ordinary freight of a van is 200 cwt., but it is obvious when this carriage is occupied by wounded men only, the springs not being depressed would shake the carriage very severely, and Herr Schmidt has arranged the leashes so that the springs can be removed in a very short time without the least fear of injury, by which means the waggon can be adapted to the weight of the wounded men, or to whatever other load there may be inside. Having said so much, however, I must after a visit to Baron Mundy's train, deplore the rudeness of the equipment of the waggon. The windows are ill fitting, accessible to every wind, to the dust and heat and rain. Of the eight litters which each waggon has to carry, four are suspended from the roof, and four are fastened on the floor, and there is nothing visible of any special arrangement for the comfort of the occupants.

Mr. Plambeck's Hamburg waggon is an ordinary van fitted up with litters secured with ropes and crammed to the roof without either light or air when the van doors are closed; but it is an example of the mode in which an ordinary railway van can be made to carry men circulating, at great discomfort, superadded to their pain, from the field of battle. It is hardly better than a straw bed at the bottom of the van.

Mr. Plambeck's Hamburg waggon.

Messrs. von Virchoff and Esmarch have designed a model of a waggon exhibited by the lower Silesian Railway Company, which is also an ordinary van with wide doors and broad platforms to allow of easy carriage of the sick and wounded. Inside there are four posts fixed and provided with hooks to which hooks corresponding are attached on the side of the carriage so that the litter can be hung up by india rubber, or leathern straps, if needed, for the transport of the wounded, and the carriage is equally available for the transport of the ordinary traffic in peace time. These fixed uprights are preferable to slung litters; all who have travelled with an ambulance train know how the wounded suffer when their litters are violently swayed, or agitated, and how necessary it is to secure them, or to hold them firmly in the hand when the train is travelling at a rapid rate over badly laid lines.

Messrs. von Virchoff and Esmarch's model waggon.

The Evans-Harris waggon was used in the Civil War of the United States, and consists of a large compartment in which 30 men can be carried at a time, with two little cribs for the surgeons, a closet, &c., provided with very broad footboard, and with good arangements for ventilation, light, and air; but it is not applicable to European railways, and it is quite impossible that 30 men crammed in together can be

Evans-Harris waggon.

in such a favourable condition for the proper treatment of their wounds as if they were distributed in three separate vans.

There were many other contributions of a similar nature, which show the importance attached by foreign governments to the combination of the transport of personnel and material with that of sick and wounded by rail in war time. In field litters there were various exhibits, from the rude contrivances sent by Spain, to the ingenious and light doolies of Baron Mundy, and Russia furnished a very complete and interesting collection of surgical apparatus and military implements, but these should have been reported on by duly qualified and competent judges, whose examination based on comparisons of all the exhibits would have been of great value.

LIEUT. ANSTEY, R.E.

THE ART OF WAR.

Report on the Principal Objects shown in Group XVI. The Art of War.—By Lieutenant T. H. Anstey, R.E.

Commencing at the west with America, we find a very small collection. A model of a counterpoise gun carriage originally mounted at Fort Foot. The calibre of the original is 15 inches, weight 50,000 lbs., weight of shot 450 lbs. and the charge 100 lbs. mammoth powder; some cavalry carbines, cartridges, uniforms, &c. The well-known Remington rifle was shown in all its different forms, Danish, Egyptian, Swedish, Spanish, New York State, and United States Government pattern. A pentagonal stand fitted up with the different parts of the Springfield rifled musket in the various stages of manufacture, and of different rifles and carbines, Remington rifle and carbine, Springfield rifle and carbine, Sharpe, Ward-Burton. Colt's patent firearm manufactory showed the "Boot" breech-loader, and some very nice revolving carbines. The sanitary collection of Dr. Thomas Evans obtained a medal of merit. The principal object contained in it was a model of a railway carriage to carry 30 invalids. The beds are arranged in three tiers longitudinally. There are five windows each provided with a louvred shutter. The wounded man need not be shifted from the stretcher on which he has been carried, as it is merely slung in its place. There were also models of a field hospital tent, and a medicine pannier belonging to Denton's United States army combined mess and medicine pannier, approved in 1864 by United States Army medical board, as being the best and cheapest. America.

Spain.

Spain showed a very nice collection in the Spanish pavilion. A bronze breech-loading gun, cast at the foundry of Seville in 1868, and the Spanish inscription on it says that it has been fired with full charge 1,412 times. Two very pretty models of rifled guns with wrought-iron carriage on wrought-iron traversing platform. Models of artillery wagons, and wrought-iron sling wagons. The Toledo arms factory sent a large collection of sword blades. Two models of field gun and team were interesting as showing the method of harnessing adopted. The ordinary hames are represented by a broad band of iron bolted to the centre of the neck collar, and a broad leather loop is attached to this. Through this loop runs a breast collar which is buckled on to the breeching. To this breast collar the pole is attached Spain. Peculiar mode of harnessing.

by a loose running buckle. All four horses have saddles, and on the pommels of both the wheelers' saddles is an iron ring through which a round bar, partly cased in thin sheet iron in the centre, and shod with brass at the ends, is run from one saddle to the other, and to the centre of this bar the pole is slung. Models of four pack mules, two of them loaded with bridge equipment on the Austrian system. One takes two trestles; the baulk and two legs on each side, and four shorter legs (beifüsse) strapped to the centre, and the other carries 18 chesses, nine on each side, and three trestle shoes strapped to the centre of the saddle. The saddle has to be specially fitted with brackets to take the load on each side, the one in rear being lower than that in front. The other two mules carried, the one a load of 16 picks and 12 shovels, the shovels had long handles, and they rested in an ellipse, the handles running through a leather band perforated for the purpose, and the other carried a tool box on each side. On the centre of the saddle of these two last mules two knapsacks were strapped. There were eight other excellent models of pack mules carrying different portions of field guns. Each takes either the two wheels, or the trail, or the gun (a rifled howitzer), or the ammunition boxes, side arms, and small stores. All these saddles are the same and are arranged specially for the purpose. They are padded with cotton at least 9 inches in thickness, and the frame taking the load rests on the pad so formed.

Pack mules.

France.

France.

France was but meagrely represented in this group. Colonel Le Mat exhibited what he calls "the American grape shot revolver." The peculiarity consists in the introduction of an additional barrel which forms the axis of the revolving cylinder; this central barrel is made solid with the frame of the revolver like an ordinary pistol, and as there is no escape of gas it can be fired with a heavy charge and swan shot cartridges. The cylinder which revolves round the central barrel is perforated for nine cartridges. The central barrel and the cylinder are independent of one another as far as the operation of loading, discharging, and extracting the expended cartridges is concerned. A movement with the thumb enables a person to fire either with an ordinary cartridge from the cylinder, or with the grape shot cartridge from the central barrel. The change is effected by a catch in the hammer. This revolver is not a self-cocker. Besides this, four military rifles sent by Guineuf, and some beautiful cartridges for military and sporting purposes by Gévelot were all that France exhibited in this group.

SWITZERLAND.

The military authorities of the Swiss Confederation exhibited a bronze field gun with new wrought-iron carriage, and the Swiss Industrial Society of Neuhausen near Schaffhausen, a rifle on Veterli's principle. It can be fired either as a repeating rifle or an ordinary breech-loader. It is adopted by the Swiss Government after having been well tested. The trials to which these arms were subjected, come under two categories, the one the results obtained by a good shot to determine the accuracy, velocity of projectile, &c., and the other the mean result from a number of weapons in the hands of indifferent shots. Besides these experiments they were subjected to other tests for durability, &c. Switzerland. Veterli's rifle.

The following is an extract from the Report of the Swiss Commission on small arms :—

A.

En présence de la susdite commission on a tiré "avec le fusil modèle No. 1 "

le mois de Septembre 1867 1,900 coups
„ „ „ Novembre 1867 4,900. „

ce qui donne y compris les coups d'essai un total de 7,000 coups ; le fusil fonctionnait à la fin tout aussi bien qu'au commencement.

" Avec le fusil No. 508 " on a tiré du 26 au 30 Novembre 1867, y compris les coups d'essais, en total 4,000 coups sans le moindre dérangement. Les essais faits avec 7 autres fusils donnent un total de 18 à 20,000 coups. Il y a eu quelques interruptions causées en partie par des cartouches défectueuses, en partie par quelques pièces délicates du mécanisme.

Ces dernières sont remplacées depuis par des pièces plus solides.

Les fusils ont été peu sensibles aux cartouches défectueuses (*à cette époque on en fabriquait encore en assez grand nombre*) et ni le tireur ni ses voisins ont été incommodés ; le jeu du cylindre obturateur ne subissait pas le moindre dérangement.

Du reste depuis qu'on se sert des douilles de Utendörfer à feu central ces inconvénients sont complètement écartés.

L'insensibilité du canon, en tirant des journées entières, c'est un mérite spécial du canon d'ordonnance fédérale, qui a été adopté avec sa munition pour le fusil à répétition. On a fait un essai de force avec 20 douilles percées—un cas où les gaz s'échappent en partie par derrière—sans avoir le moindre dérangement du mécanisme qui fonctionnait avec facilité après quelques maniements du cylindre. *C'est une qualité*

exceptionelle qui fait défaut à tous les autres systèmes de fermeture existants.

Pour un autre essai on a éparpillé du sable humide dans le mécanisme et exposé le fusil ainsi à la pluie et au froid pendant plusieurs nuits ; ensuite après avoir jeté de l'eau sur l'arme rouillée, et sans en démonter une seule partie, on s'en est servie pour faire un feu de vitesse qui a parfaitement réussi.

Ces essais de force ont écarté tout scrupule contre la sûreté du système de fermeture. L'obturateur a tant de jeu dans son mouvement qu'après l'essai avec les douilles perçées il n'y avait point de difficulté pour le faire entrer et sortir. L'extraction des douilles vides se fait sans aucun mécanisme artificiel ; l'appareil d'extraction est simplement fixé au cylindre qui en sortant retire sans faute la douille ; par le mouvement montant du transporteur cette dernière est rapidement écartée.

Cette fonction s'opère d'une manière infaillible et énergique. L'exercice de peu d'heures suffit pour mettre des recrues au courant du démontage, nettoyage et remontage de l'arme.

B.—Vitesse du Tir.

Les tableaux suivants donnent les moyennes du feu de vitesse résultant des sousdits essais ; le premier contient les détails du tir de quelques soldats peu exercés, le second ceux obtenus par un bon tireur.

Résultats de tireurs peu exercés.

Distance 300 pas.

Manière de Charge et de Feu.	Vitesse ou Nombre de Coups par Minute.	Point Touché °/o	Grandeur de Cibles.	Moyennes obtenues.	
				Sur Nombre de Coups.	Avec Hommes.
Simple charge, feu de salve, sur commando.	6·7	66	1·8m/5·4m	600 (séries à 20).	6
Simple charge, feu sans commando.	8·5	52	1·8m/5·4m	380 (séries à 14 et 20).	6
Idem - - -	9	59	1·8m/1·8m	384 (séries à 20).	5
Charge du magasin, feu sans commando.	13	57	1·8m/5·4m	350 (séries à 14).	6
Sur cibles spéciales, par homme.	12	63	1·8m/1·8m	212 (séries à 14).	5
Charge du magasin et 11 coups charge simple.	9·9	53	1·8m/1·8m	700 (séries à 25).	5
Charge du magasin, feu de salve, sur commando.	15	61	1·8m/5·4m	480	5

RÉSULTATS D'UN BON TIREUR.

Distance 300 pas. Grandeur de cible $1{\cdot}8^{m}/1{\cdot}8^{m}$.

Manière du Chargement et du Tir.	Vitesse ou Nombre de coups par Minute.	Point touché °/₀	Extension de l'Essai.	
			Coups.	Séries.
Simple charge:—				
a. Debout - -	13	100	78	3
b. Agenouillé - -	10·6	100	67	2
c. Couché - -	10·7	100	40	1
Charge du magasin avec 14 cartouches:—				
a. Debout - -	14 coups en 40 secondes ou vitesse de 21 coups.	100	95	7
b. Agenouillé - -	14 coups en 42 secondes ou vitesse de 20 coups.	100	42	
c. Couché - -	14 coups en 36 secondes ou vitesse de 23 coups.	100	70	
Charge du magasin et suite à simple charge.	17	98	45	2
Charge du magasin, feu en avançant.	19	100	30	1
Charge du magasin, et rechargement du même.	12	100	34	1
Tir de vitesse sans viser:—				
a. Charge du magasin	$39\frac{1}{3}$	—	48	2
b. Charge simple -	$27\frac{1}{2}$	—	54	2

Pendant toute la période de ces essais, outre le canon, le mécanisme n'a jamais été nettoyé quoique bon nombre de cartouches ait crevé; la fuite des gaz n'avait point d'influence sur la manipulation des parties mobiles, le mécanisme de percussion étant indépendant et à l'abri de toute influence extérieure et intérieure.

Il résulte de ce rapport que le problème de combiner la répétition avec le système du fusil Suisse par un mécanisme peu compliqué peut être considéré en général comme bien résolu. Le point essentiel c'est que le fusil ait subi des épreuves sérieuses et pratiques d'une manière très-satisfaisante.

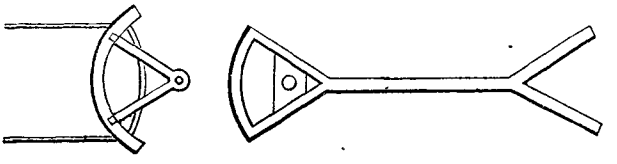
Le dit fusil se range parmi ceux d'ordonnance Suisse; comme arme à simple charge elle a une vitesse de tir qui n'est surpassée par point d'autres systèmes, comme arme à répétition elle les surpasse tous. Grâce aux études et perfectionnements appliqués successivement par la dite commisson ainsi que par le constructeur, elle est reconnue aujourd'hui sous tous les rapports comme arme de guerre solide et pratique et comme telle elle peut être recommandée avec pleine conviction.

SWEDEN.

The objects exhibited by Sweden were both varied and interesting, there being a war pavilion purposely constructed. In this every branch of the army was represented, and a Swedish artilleryman in full uniform was in charge of the whole show. The artillery was represented not only by guns of every description, but by full sized models of a team of horse artillery.

Method of attaching carriage to limber.

In rear of the limber to which this team was harnessed stood a field gun and ammunition wagon. The accompanying small sketch shows how the ammunition wagon is attached to the limber by a perch pivotting on a pin.



Perch attached to Ammunition Wagon.

Artillery harness.

The chief points to be noticed in the harness of the team are, that the driver's sword is strapped to the pommel of the saddle on the near side. The neck collars have no hames, all the leather and iron work is black, the breeching strap is permanently attached to the collar. The pole is fastened to a breast collar in rather a peculiar manner. A triangle, two sides made of wrought iron and the third of wood, is fastened at the angle formed by the two iron sides to the pole, the triangle being able to pivot freely on that point, the two other angles are attached to the breast collars by means of a D running freely on them. The traces, which are made of rope, are also blackened.

M.L.R. field gun.

A cast-iron muzzle-loading field gun sawn in half, with its shot laid in the groove, was exhibited to show how far it had been affected by the firing it had undergone. 1,300 shots had been fired from it, of which 1,200 were with a charge of 1·1 kilogrammes and 100 with a charge of from 1·3 to 1·5 kilogrammes. These last were the commencement of a series of experiments to see how far the charge could be increased without straining the gun. The pressure of the powder on the breech was measured with the "crusher." The diameter was 9·6 c.m., weight 640 kil., greatest thickness of metal, 1·105 calibre; smallest thickness, 0·47 calibre; length of bore, 18·5 calibre; weight of shell, 7·8 kilogrammes; service charge, 1·1 kilogrammes; initial velocity, 840 metres; permanent deflection on 1,000 metres 0·36 metres; on 2,000, 1·04 metres; angle of elevation on

1,000 metres, 2° 45′; 2,000 metres, 6° 31′. The effect of the powder had been inappreciable. The war department sent various objects, such as specimens of smiths' tools used by the artillery, a cavalry saddle, and a very ingenious cartridge filler. The company for the manufacture of small arms at Husqvana, showed the Remington rifles and carbines in all stages of construction. This is a very important company, employing in their workshops 360 men and 55 children under 15. The machinery is driven by water, which is available up to 4,000 horse-power, 200 being actually used. 30,000 rifles are turned out yearly at a price of 45 rix dollars, with 4 per cent. discount on large orders. A peculiar mitrailleuse, invented by Palmcrantz, and which is said to fire with extraordinary rapidity, attracted considerable attention, though its mechanical details are kept secret. It consists of 10 barrels in the same horizontal plane, the individual firing having the power to splay them to a certain extent outwards by turning a small wheel in rear. The cartridges are contained in a series of metal cases bound together in a frame and fixed in a vertical position over the breech, with 250 cartridges in each lot of tubes, and the action of firing is performed by the horizontal movement backwards and forwards of a long lever arm. It is said to have found favour with the Danish Commission appointed to examine this species of weapon, beyond all others. It strikes one, however, that should the ground not be level, especially when the barrels are a little splayed outwards, most of the shots would be wasted.

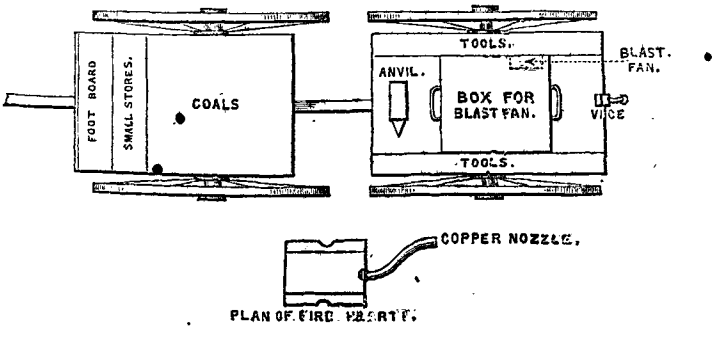
Husqvana rifle factory.

A forge wagon of good construction (see Figs. 1 & 2) and a pioneer wagon, as well as a field telegraph, two sorts of pontoons with their wagons, and an artillery artificer's wagon,

Forge wagon.

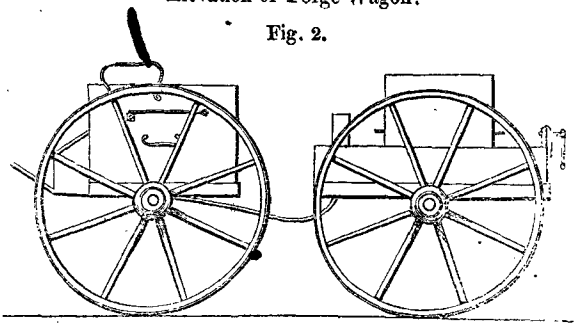
Fig. 1.

Plan of Forge Wagon.



Elevation of Forge Wagon.

Fig. 2.

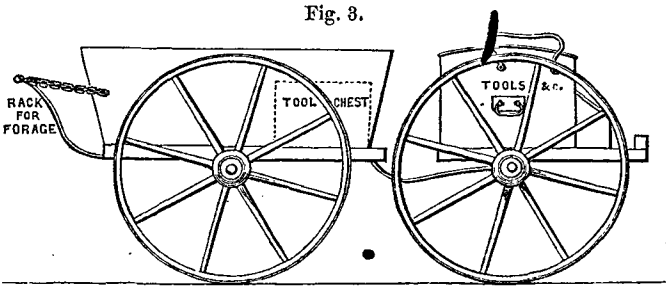


were also shown by the Swedish war department. The forge wagon consists of a body on two wheels and limber. On the limber the coals are carried, and on the body two long *tool* boxes, the anvil and block, vice and fire-hearth. The bellows are dispensed with, the blast being obtained by a rotatory fan contained in a box, the fire-hearth hanging on to it, and a copper tube communicating the blast. A great deal of space is saved by this arrangement, the big bellows used by us being dispensed with. The pioneer wagon is made of iron, the fore part of an iron pontoon serving as the body, and a limber hooking on to it. The pontoons and system of packing is very nearly the same as the Austrian, one of them, however, being the peculiarity of having iron wheels, which are inside the pontoon, which when inverted and in its place on the wagon hangs down over them. They are driven by one man. A new brake was attached to one of them; its peculiarity consists in its being made to act by the horses themselves, *i.e.*, the more they push back the more the break acts on the wagon. This is a doubtful innovation, and does not dispense with the safer brakes in ordinary use. The field telegraph is like those in use in our own service. It has seven drums and carries 10,000 yards of galvanized 4-stranded iron wire. A Swedish telegraph division consists of two office wagons, two wagons each carrying 150 ordinary poles and 20 tubular telescopic ones, and two wire wagons each with 10,000 yards of wire and the necessary tools. Where it is impossible to pay out the wire from the wagon direct, the drum is carried by two men provided with the necessary straps to hold it. The artillery artificer's wagon is of simple construction. (See Fig. 3.) It is the pattern generally adopted throughout the Swedish service for general service wagons. The body is a cart on two wheels, the fore part being a limber.

Artillery artificer's wagon.

Side view of Artillery Artificer's Wagon.

Fig. 3.



Of the siege guns exhibited three were rifled as are the field guns on Riffel's system. Their calibres are, 12·18 c.m., 16·72 c.m., and 20·23 c.m. The two first are of cast iron, weighing 1,700 and 4,200 kil. respectively. The 20·23 c.m. gun is of Bessemer steel, strengthened by rings shrunk on, and weighs 7,600 kil. Besides these there were exhibited some old smooth bores and mortars. All these last were from the Finspong foundry. Siege guns.

Russia.

The Russian contributions were numerous and excellent. Commencing with the guns, we have a big breech-loader on Krupp's wedge system. It is made out of a block of cast steel, strengthened by rings of the same metal, four in number at the breech, diminishing to one at the muzzle. The resistance of the gun to the limit of elasticity is 4,652 atmospheres. Russia. Cast-steel B.L. guns.

Its weight, together with the closing wedge, is 40,491 kil.
Calibre, 304 mil.
Weight of charge, 51·6 kil. prismatic powder.
Weight of steel shell, 294·8 kil.
Initial velocity of shell, 426 metres per second.

It has 36 grooves. The next in size is an 8-inch, likewise made from a block of cast steel, strengthened at the breech by one ring of steel. Its resistance to the limit of elasticity is 3,067 atmospheres. The weight of the gun is 8,933 kil. with its breech-closing wedge. This piece had been fired 1,243 times with chilled shells 77·8 kil. in weight with the following charges of prismatic powder :—

16 to 25 lbs.	-	16 shots.
12·89 kil.	-	684 „
13·50 „	-	191 „
14·332 „	-	109 „
15·561 „	-	243 „

The initial velocity from the service charge of 15·561 kil. is 440 metres per second. It has 30 grooves. Next in size is a 6-inch (152 mm.) breech-loader, made like the last of steel, with only one strengthening ring. Its resistance to the limit of elasticity is 2,957 atmospheres; weight, 4,000 kil.; with a gun of similar construction 684 shots have been fired, of which 607 were with the service charge of 8·19 kil. of prismatic powder, and nine with charges from 6·55 to 8·19 kil. The shell weighs 36·85 kil.; the initial velocity with this last charge was 487 metres, and the pressure of gas 3,000 atmospheres; it has 24 grooves. Next we have a steel breech-loading 8-inch rifled mortar; calibre, 203 mm., strengthened by one steel ring. Its resistance to the limit of elasticity is 2,424 atmospheres. It weighs 3,276 kil., and the service charge is 7·361 kil. of prismatic powder. The shell weighs 77·8 kil.

A 4-pounder (*canon de* 4) breech-loader is the last of the exhibits of the great steel foundry of Oboukhoff at St. Petersburg, to which all the above guns belong. Its weight is 360 kil.; weight of shell, 5·527 kil.; calibre, 86 mm. This gun has been fired 1,034 times as follows:—

3	times	with 614·2	grammes	L. G. powder.
3	„	819	„	„
3	„	1,023·7	„	„
3	„	1,228·5	„	„

This was before it was rifled, and after that the remaining shots were with the service charge of 614 gram. L. G. powder. Some rifle barrels were also sent from the same foundry.

A large 9-in. steel breech-loader was exhibited without any description being given. The arsenal of St. Petersburg sent a bronze rifled field gun (*canon rayé de* 4) complete with wrought-iron carriage, limber and pole; and a bronze mortar, 6-inch, with heavy wrought-iron bed, fitted with limber for travelling. It is a wedge breech-loader. Five horses draw this mortar, two being wheelers and three leaders. All the projectiles are lead coated. From the same place were sent a collection of Krink carbines (*fusils de dragons*) with browned bayonets attached. An ambulance wagon was much approved. It is for four men, two lying on the floor, and two slung above them to the frame of the wagon cover and to an iron support in front in the centre of the carriage. The stretchers are fitted with springs, and run on castors. The jury awarded it a medal of merit.

Colonel Lischine's marquees, &c.

The model of an ambulance tent on Colonel Lischine's system found favour, and is very peculiar. Instead of being made of canvas or jute, he uses laths strung together, overlapping each other like venetian blinds. The ridge is canvas.

The frames are of iron, four in number. The following are the points to which attention is called:—

1. The construction of this covering material being very simple may be left to the soldiers themselves.

2. It can be rolled up, and takes up but little room, each strip being three metres long and one foot broad. A baggage wagon could carry from 150 to 200 such strips.

3. It is twice as durable as any linen or canvas, which under favourable circumstances only last four or five years.

4. It can be painted to preserve it still more from wet and the effect of the sun.

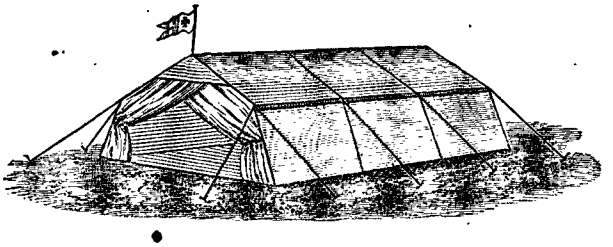
5. Pine being the cheapest, the lightest (of ordinary woods), and the least subject to atmospheric influence, is the wood to suit best.

6. Being painted there is no fear of its being damaged by wet, and it can be rolled and packed immediately after rain without the least fear of its being damaged (a great advantage over canvas).

7. The construction is very simple, it can be easily put up and moved from place to place.

8. Old canvas after being quite unfit to be used by itself can be made available as an extra covering in winter, keeping in the heat, though by itself unable to keep out the wet.

The accompanying plates will speak for themselves. There is little doubt that for camps of instruction these would be very useful, as to a great extent they render them independent of the time of year selected for camping. The name given in French by the inventor is "Toitures écaillées en planchettes de bois appropriées aux tentes baraques à charpente de fer." It is patented at St. Petersburg.



A model was also exhibited of a divisional ambulance marquee for three wounded officers. It has a double roof, the exterior covering necessitating the use of a double row of pickets. The walls were lined with coarse woollen cloth. A pretty model of a pontoon bridge on the well-known Austrian (Birago's) system, a collection of rifles on

Mode of pontoon bridge.

Berdan's system, and four models of pack horses with the different portions of a 3-inch rifled gun and carriage completed the objects sent by Russia. It may be mentioned that the pack saddle consisted merely of several layers of blanket with a thick leather shield over all.

GERMANY.

Germany. Germany was more richly represented in guns than any other power. The post of honour must be accorded to Krupp. Messrs. Krupp, for though there are other firms capable of turning out very good work, yet Krupp of Essen is *facile princeps*. The pavilion in which his steel work was exclusively exhibited showed every variety of object to which steel could be applied. The first object was a block of crucible cast steel destined eventually to be worked [illegible] a gun, 37 c.m. calibre, (about 14 inches,) 1,800 crucibles each containing about 60 lbs., were used in casting the block, which, originally round, was worked into its present octagonal shape under a 50-ton steam hammer to show the malleability of the material. Its weight was 52½ tons. Statistics published by Messrs. Krupp show that the firm exhibited—

In London	in 1851	a block	weighing	2¼	tons.
„ Paris	„ 1855	„	„	10	„
„ London	„ 1862	„	„	20	„
„ Paris	„ 1867	„	„	40	„

All the guns except those of the smallest calibres are constructed on the built-up principle with Krupp's round wedge breech closing system.*

Commencing with the biggest gun, we have a—

30½-c.m. GUN ON COAST CARRIAGE.

Length of gun, 6·7 m.
„ bore, 5·77 m.
Weight of gun with wedge, 36,600 k.

The gun has 72 parallel grooves with 4·5 mm. width of lands, and a uniform twist of 21·76 m. in length.

Weight of charged steel shell	296 k.
„ charge (prism. powder)	60 k.
Initial velocity, 465 m.	
Weight of charged common shell	257 k.
„ charge (prism. powder)	50 k.
Initial velocity, 460 m.	

* The following description of the gun, &c., is taken from Mr. Krupp's published pamphlet.

The carriage is intended for earth parapets of 1·9 m. height, and has a height of 2·380 m. To check the recoil, a hydraulic buffer is used.

The projectile is lifted by means of a movable crane with windlass, which is arranged on the right-hand side of the slide, and brought up to the muzzle of the gun.

The elevation (+ 17°,—7°) is taken by means of a toothed elevating arc on the upper part of the carriage. For training the end of the slide is provided with a chain gear.

By this apparatus the gun can be very easily and quickly served.

To run-in the gun, a rope-windlass may be placed, if necessary, on each side of the slide behind.

Weight of carriage - - -	5,650 k.
,, slide - - -	15,350 k.
Total weight - - -	21,000 k.

28-c.m. Howitzer on Coast Carriage.

The gun is constructed for being placed in coast batteries.

Length of gun, 3·200 m.
,, bore, 2·520 m.
Weight with wedge, 10,000 k.
Preponderance 0.

The gun has 72 parallel grooves with 4·5 mm. width of lands, and a uniform twist of 11·2 m.

Weight of charged common shell	199 k.
Maximum weight of charge - -	20 k.

The carriage of the gun admits of an elevation of 75°.

The carriage differs from the coast gun carriages principally, in that the whole of the under-face of the slide lies in the platform on firing, so as to extend the impact of recoil over a larger surface.

The projectile-crane, training-gear, hydraulic buffer and self-acting running-out apparatus are the same as in the other coast gun carriages. The elevating gear is also similarly constructed.

Weight of the whole carriage, 9,220 k.
Height, 1·675 m.

Short-26 c.m. Ship-Gun on Battery Carriage.

Length, 5·2 m.
Length of bore, 4·420 m.
Weight of gun with wedge, 18,000 k.

The gun has 64 parallel grooves with 4·25 mm. width of lands, and a uniform twist of 18·2 m.

Weight of charged steel shell - - 184 k.
„ charge (prism. powder) - 37·5 k.
Initial velocity, 450 m.
Weight of charged common shell - 159 k.
„ charge (prism. powder) - 30 k.
Initial velocity, 450 m.

This gun has a carriage for use in a broadside battery of ironclads. The carriage differs from the former ship carriages for similar purposes principally, in that the hydraulic buffer and apparatus for self-acting running-out are contrived similarly to those of coast gun carriages. The hydraulic buffer is so arranged, that the gun with the upper part of the carriage can be retained at once on any part of the slide.

The training is effected by a cog wheel, which works into a cog racer in the deck and is moved by a worm wheel, so as to dispense with an especial brake to retain the gun in the required direction. For elevation there is arranged on both sides of the gun a cogged elevating arc; both are, however, moved simultaneously from the left side of the carriage by a hand wheel. In order to relieve the ship's side in firing, the recoil is partially received from the grooved rollers by ribs on the upper face of the deck racers and from a strong hook which ties the fore-part of the slide down to the strong projecting lip of the front racer.

Total weight of carriage, 8,756 k.
Height, 1,220 m.

Long. 24 c-m. Gun on Battery Carriage for Casemate Ships.

Calibre, 235·4 mm.
Length of gun, 5·23 m.
„ „ bore, 4·54 m.
Weight of gun with wedge, 15,500 k.
Preponderance 0.

The gun has 32 grooves, whose breadth increases towards the breech with a width of lands of 3·9 mm. at breech and 7·85 mm. at mouth. The twist is uniform of 16·48 m. length.

Weight of charged steel shell - - - 135 k.
„ „ charge (prism. powder) - - 24 k.
Initial velocity, 430 m.

Weight of charged common shell - - 118·5 k.
„ charge - - - - 20 k.
Initial velocity, 424 m.

The gun is mounted on a battery carriage for casemate ships. Owing to its position in one of the obtuse angles of the casemate so as to be capable of firing through a broadside and a bow or stern port, it was necessary to make arrangements for a change of ports. This is done by means of a turntable, on which the gun rests with the middle slide supports and the rear slide rollers, after the fore slide rollers have been lifted correspondingly by an hydraulic lifting-jack, fixed under the slide for this purpose. To facilitate the unshacking of the pivot-bar on the change of ports it is divided, and at the joint a bolt easy of removal is put on

To check the recoil, the carriage is provided with an adjustable plate compressor. A chain running-in-and-out-gear is applied on both sides of the slide end. For training, the pinion of the cog racer is moved by the same cranks, which are used for the above mentioned chain gear.

The elevation is taken by means of a cogged elevating arc.

Weight of carriage - - - 2,344 k.
„ slide - - - - - 5,466 k.

Total weight - - - - 7,810 k.
Height, 1,195 m.

LONG 21-c.m. GUN ON COAST CARRIAGE.

Calibre, 209·3 mm.
Length of gun, 4·708 m.
„ bore, 4·106 m.
Weight of gun with wedge, 10,000 k.

The gun has 30 grooves whose breadth increases towards the breech, with 3·4 mm. width of lands at breech, and 7·3 mm. at mouth. The twist is uniform of 14·23 m. length.

Weight of charged steel shell - - 95 k.
„ charge (prism. powder) - 17 k.
Initial velocity, 430 m.
Weight of charged common shell - - 79 k.
„ charge - - - 14 k.
Initial velocity, 430 m.

The gun is mounted on a coast carriage of a description similar to that of the 30½-c.m. gun.

Height 2·015 m.	
Weight of carriage - - -	2,090 k.
„ slide - - -	5,110 k.
Total weight - - - -	7,200 k.

21-c.m. SEIGE GUN WITH SLIDE CARRIAGE.

Calibre, 209·3 mm.
Length of gun, 3·400 m.
„ bore, 2·910 m.
Weight of gun (with wedge), 3,900 k.
Preponderance 0.

The gun has 30 grooves whose breadth increases towards the breech, with 3·7 mm. width of lands at breech, and 7·5 mm. at mouth. The length of twist is 12·36 m.

Weight of charged common shell -	79 k.
„ charge (prism. powder)	6·5 k.

Initial velocity, 300 m.

The carriage for this gun is a short slide carriage, in all essential points similar to the coast carriages. The slide, when in battery, rests in front on the pivot block, behind on two rollers which can be moved, for the purpose of training, by means of handspikes. The cogged elevating arc admits of 27° elevation and 6° inclination. The projectile crane, hydraulic buffer &c., are similar to the coast carriages. This gun can be made available for transport. For this purpose a strong axle with large wheels is placed in the axle supports, after the gun and carriage have been run up on the slide: then the fore-end of the slide is raised by means of a lifting apparatus, which is permanently fixed on the slide, consisting of a screw with worm-wheel gearing; and finally the rear-end of the platform is limbered up. The transport rear wheels have a diameter of 2·046 m. and a breadth of 0·180 m. in the rim. The distribution of the weight resting on hind and fore-wheels is in proportion of 4 : 1. To lighten the transport wagon, the slide rollers may be carried separately. The projectile crane may be turned over. For transport by rail, the limbered-up carriage can be easily placed on a 10-ton luggage wagon. The bed, made of oak beams and provided with pivot block and racer, can be carried on an ordinary lugage wagon. As soon as the gun has been carried to its proper place over the bed in the battery, it is

unlimbered, and then the rear slide rollers are lowered down on the racer by means of a windlass; the slide is afterwards let down in front upon the pivot block, and the transport axle and wheels are removed.

Height in battery, 1·9 m.

Weight of carriage - - - -	922 k.
„ slide - - - -	1,728 k.
Total weight - - - -	2,650 k.
The limbered-up gun with side-arms weighs -	8,160 k.
The bed complete weighs - - -	2,080 k.

LONG 17-c.m. GUN ON UPPER DECK CARRIAGE.

Calibre, 172·6 mm:
Length of gun, 4·250 m.
„ bore, 3·780 m.
Weight of gun with wedge, 5,600 k.
Preponderance 0.

The gun has 48 parallel grooves with 3·5 mm. width of lands, and a uniform twist of 11·2 m.

Weight of charged steel shell - -	55 k.
„ charge (prism. powder) -	10 k.
Initial velocity, 460 m.	
Weight of charged common shell - -	45 k.
„ charge (prism. powder) -	10 k.
Initial velocity, 465 m.	

The upper deck carriage for this gun is to be placed in the bow or stern of ironclads and provided with contrivances so as to be moved easily and quickly. To check the recoil, a plate compressor is used.

Height, 1·020 m.

Weight of carriage - - -	1,255 k.
„ slide - - -	2,235 k.
Total weight - - - -	3,490 k.

15-c.m. SIEGE GUN ON WHEEL CARRIAGE.

Calibre, 149·1 mm.
Length of gun, 3·44 m.
„ bore, 3·040 m.
Weight of gun with wedge, 3,000 k.
Preponderance one metre from the trunnion, 25 k.

The gun has 36 grooves with 3 mm. width of lands at breech, and 5·5 mm. at mouth. The length of twist is 9·7 m.

Weight of charged common shell - - 28 k.
„ charge (prism. powder) - 6 k.
Initial velocity, 470 m.

The carriage for this gun is constructed as a wheel carriage. The brackets are made of plates and angle-iron. The elevating screw admits of 35° elevation and 5° inclination. As a peculiarity in this carriage may be named the hydraulic buffer, which, on discharge, checks the recoil to about one metre or less. The buffer cylinder can be moved vertically, being fastened to the brackets at one-third of their length from behind. The piston rod can be moved vertically and horizontally, by means of a pivot bolt connected with an anchor, partly imbedded in the parapet.

Height, 1·830 m.
Weight of carriage - - - 1,845 k.

Long 15-c.m. Gun on Ship Carriage.

Calibre, 149·1 mm.
Length of gun, 3·85 m.
„ bore, 3·43 m.
Weight of gun, (with wedge), 4,000 k.
Preponderance at the commencement of the rounding of the wedge, 75 k.

The gun has 48 parallel grooves with 3 mm. width of lands, and 9·7 m. length of twist.

Weight of charged steel shell - - 35 k.
„ charge (prism. powder) - - 8 k.
Initial velocity, 490 m.
Weight of charged common shell - - 28 k.
„ charge - - - - 6·5 k.
Initial velocity, 465 m.

The carriage of this gun is made for broadside use on sloops of war and similar vessels. It is a slide carriage. To check the recoil, a plate-compressor is used, and a breeching as reserve. The elevation is effected by a cogged elevating arc and the training by means of tackles, for which side eyes are provided on the rear end of the slide. The slide rests usually on supports on the racers; for training, it is lifted upon the rollers.

Height, 0·960 m.
Weight of carriage - - - 1,505 k.
„ slide - - - 935 k.

Total weight - - - - 2,440 k.

12-c.m. Gun on Ship Carriage.

Calibre, 120·3 mm.
Length of gun, 2·925 m.
„ bore, 2·602 m.
Weight of gun (with wedge), 1,400 k.
Preponderance, 100 k.

The gun has 18 grooves, whose breadth increases towards the breech, with 2·5 mm. width of lands at breech, and 6·5 mm. at mouth. The length of twist is 8·42 m.

Weight of charged steel shell - -	15·5 k.
„ charge (large-grained powder)-	3·5 k.

Initial velocity, 450 m.

Weight of charged common shell -	15·5 k.
„ charge (large-grained powder)-	3 k.

Initial velocity, 450 m.

The carriage for this gun is a wheel carriage constructed for the main or upper deck of small vessels. To check the recoil, a hydraulic buffer is applied, similar to that of the 15 c.m. siege carriage. The buffer cylinder, movable vertically and horizontally, hangs on the pivot bolt; the piston rod is fastened to the carriage. A strong breeching is provided as reserve. The carriage rests usually on four rollers; for training, the rear rollers, which are mounted excentrically, are lifted, whereby the weight is transferred to a training roller.

The elevation is taken by means of a cogged elevating arc, which admits of + 15° and − 10°.

Height, 0·900 m.
Weight of carriage, 895 k.

9-c.m. Field Gun with Carriage.

Calibre, 91·5 mm.
Length of gun, 20·40 m.
„ bore, 1.819 m.
Weight of gun (with wedge), 425 k.
Preponderance, 50 k.

The gun has 16 grooves, whose breadth increases towards the breech, with 2·5 mm. width of lands at breech and 6·5 mm. at mouth. The twist is 4·53 m.

Weight of charged shell - -	6·9 k.
„ charge (cannon powder) -	0·6 k.

Initial velocity, 322 m.

The gun carriage has riveted wrought-iron brackets. Weight of carriage (without accessories) 546 k. The elevating screw admits of an elevation of $+15\frac{3}{16}°$ and $-8°$.

8-c.m. Field Gun with Carriage.

Calibre, 78·5 mm.
Length of gun, 1·935 m.
„ bore, 1·728 m.
Weight of gun, 295 k.
Preponderance, 70 k.

This gun has 12 grooves, whose breadth increases towards the breech, with 2·5 mm. width of lands at breech, and 6·5 mm. at mouth. The twist is 3·62 m. long.

Weight of charged shell - - - 4·3 k.
„ charge (cannon powder) - 0·5 k.
Initial velocity, 357 m.

The carriage for this gun has also riveted brackets. Weight of carriage (without accessories) 460 k. The elevating screw admits of $13\frac{15}{16}°$ elevation and 8° depression.

6-c.m. Mountain Gun on Carriage.

Calibre, 60 mm.
Length of gun, 1·250 m.
„ bore, 1·130 m.
Weight of gun (with wedge), 107 k.
Preponderance, 14 k.

This gun has 18 parallel grooves with 3 mm. width of lands, and 2·10 m. length of twist.

Weight of charged shell - - - 2·3 k.
„ charge - - - 0·2 k.
Initial velocity, 300 m.

The carriage has wrought-iron brackets, cast-steel axle and wooden wheels. On the naves of the wheels there are conical friction brakes.

Weight of carriage, 109 k.
Height, 0·660 m.

The elevating screw admits of 21° elevation and 10° depression.

Broadwell's expansion ring is used in all these guns.

Remarks on Krupp's factory.

Krupp's cast steel factory near Essen was established in the year 1810. In the year 1826 it was conducted by Alfred Krupp, and in 1848 he took it on his own account. In January of the year 1873 the works, which have steadily

developed, covered an area of more than 4,784,000 square yards, of which 900,000 are covered in. 12,000 workmen are employed, independently of some 2,000 more supplied by contractors. The number of officers and fixed employés is at present 739. In the mines and smelting works belonging to the firm there are employed a further number of about 5,000 men. The quantity of cast steel produced in 1872 was 125,000 tons.

Bochumer Verein.

The next in importance is the Bochumer mining and cast steel company, (Bochumer Verein für Bergbau und Gussstahl fabrication). They showed a marine gun of cast steel on the built-up system strengthened by three rings at the breech; calibre 21 c.m. It had been fired 500 times by the Prussian artillery test commission for durability, and 50 times for testing strength.

A 15-c.m. gun for coast defence on the same principle; the weight of the first is, with its carriage, 10,000 kil., that of the second 3,000 kil., and two field guns with steel carriages, a 6- and a 4-pounder. The steel factory has been in existence for 30 years, and the present company took it over 18 years ago. The property extends over 140 hectares; the number of foremen and employés is about 250, with 6,000 workmen. 11 million pounds of a value of 700,000 thalers, are made monthly; 96 million pounds were made in the year 1872 with a value of six million thalers. All these guns have Broadwell's breech-loading system.

Witten Arm factory.

The next in importance is the exhibition of the cast steel and arms company at Witten on the Ruhr in Westphalia. This firm exhibit two 8-c.m. steel field pieces, and one 9-c.m. unmounted. The construction is the same as that adopted by the Prussian Government, but instead of having Kreiner's double wedge breech-closing system, they have Broadwell's steel expansion ring and single wedge. The dimensions are,

	8-c.m.	9-c.m.
Calibre	78·5 mm.	91·5 mm.
Length rifled	1512 mm.	1603 mm.
Number of grooves	12	16
Length of twist	3624 mm.	4523 mm.
Angle of twist	3° 55′	3° 40′
Whole length of barrel	1928 mm.	2040 mm.
Weight without wedge	274 kg.	414 kg.
Weight with wedge	285 kg.	430 kg.

Another gun of 8-c.m. is strengthened by a cast-steel ring wrought and shrunk on. The method of firing is peculiar

(Cæmmerer-Schmidt's principle). The channel for the tube goes vertically straight into the wedge, and thence right into the chamber for the charge. An 11-inch detonating fuze is introduced and fired by a lock on the needle-gun principle. It is provided with a self-acting extractor. In the opening in the wedge a steel loading cylinder is introduced, moveable backwards and forwards to prevent the Broadwell ring from falling out. The cartridge chamber is made larger at the base in order to admit of a greater charge than can be generally used.

Calibre - - -	81 mm.
Length rifled - -	1515 mm.
Number of grooves -	18
Length of twist - -	3766 mm.
Angle of twist - -	3° 50′
Whole length of barrel -	2112 mm.
Weight with wedge -	429 kg.

Greatest charge of Belgian L.G. powder, 1·1 kg. The projectile is a cast-iron shell with thin lead coating and percussion fuze, rounded at the base, 2½ calibres long, with a weight when loaded with 250 gr. bursting charge, of 5 lbs. The initial velocity is 500 m. and at 1,200 paces 440 m.

A 6½-c.m. mountain gun was also exhibited. It is the same as those which composed a battery lately sent to La Plata. A mule carries the gun, another the carriage, and a third the ammunition. It was designed by a Swiss officer, Major Gressley. The factory was established in the year 1854, by the late Mr. Carl Berger, and has come into possession of the company quite lately. It gives at present employment to about 600 workmen, and has 12 steam hammers from 3 to 300 centners, 20 steam engines, 2 locomotives, 57 different furnaces, and about 260 working machines of sorts. It is divided as follows:—

1. The *fire-brick* factory which makes not only enough for home consumption, but sells large quantities as well.

2. The *crucible* factory makes nothing but crucibles for the manufacture of cast steel.

3. The *cast steel* factory, working with Siemens' blast furnace.

4. The *hammer work* and *fine rolled work* (Walzwerk) finishes wrought pieces of engines, and war material, as well as round, flat, angular, and curved steel.

5. The *sheet-iron work* rolls sheet steel, and fine sheet iron.

6. The *barrel boring* work does the complete working up of rifle barrels.

7. The mechanical workshops are arranged for making cannon and parts of machines, as well as doing the repairs of the whole establishment.

A rifle factory on an American system is now in course of construction, with a great many tool-making machines, a number of steam hammers and other arrangements to admit of the construction of 60,000 rifles yearly. It will cover an area of 5,000 meters. The sheet steel made is used for the cheeks of field-gun carriages, targets, cuirasses, sword guards, saddle-trees, &c.

Near the objects exhibited by the two last firms stood a rifled mortar of peculiar construction by Cæmmerer-Schmidt. It consists in a barrel of cast steel screwed into a breech which in this instance is of the same metal, but which need not of necessity be of steel, as one of the advantages claimed is the ease with which old cast-iron mortars may be converted. In unscrewing it, the barrel turns down by means of a hinge, and the charge is placed in the base. The escape of gas is prevented, not by the screw, but by a leather ring steeped in tallow fat placed between the base of the barrel and a correspnding hollow in the chamber, and jammed fast by means of the screw, which is worked by two handles at the muzzle. In consequence of the change in position the barrel cannot be provided with a fixed foresight, but a separate pendulum sight has to be used. The elevation, ranging from 30° to 75°, is given by a simple screw.

Its dimensions are as follows:

Calibre - - -	91·5 mm.
Length rifled - - -	647 mm.
No. of grooves - - -	16
Length of twist - - -	2300 mm.
Angle of twist - - -	7° 10′
Weight with breech - -	123 kgs.
Greatest charge of common powder	200 gr.

Its projectile is a cast-iron shell 2½ calibres long with thin lead coating and percussion fuze. It weighs 6 kgs. having 500 gr. bursting charge. This shell is peculiarly shaped in order to preserve the axis parallel to the first line of flight, and is therefore, as the exhibitors themselves admit, only to be used against bodies of troops. It can be easily carried by four men, and is in consequence a useful weapon in a siege being easily shifted from one spot in the trenches to another. It is available from 1,000 to 4,000 paces.

Italy.

Italy.

The display in the Italian section was small and unimportant. Of guns, there was a large natural sized wooden model of a gun for coast defence, and a small bronze muzzle-loading naval field gun, on the system of Mattei Rossi with iron carriage and ammunition boxes, and fitted with a pair of shafts. Besides these, different portions of uniforms were shown, and the Committee of Military Engineers showed a book of plates descriptive of field telegraph arrangements, instruments, tents, &c.

Hungary.

Hungary.

The Hungarian show of military objects was limited to a very tasteful group of Honveds, life-sized models representing every arm of the service. No other country showed anything else of note but England.

England.

England

Commencing with the charming collection of guns shown by Sir William Armstrong & Co.

The following description of the capabilities of this great firm has been furnished me, and will be of interest as a comparison with the capabilities of some of the large foreign firms mentioned in these pages.

The Elswick works at Newcastle-on-Tyne, England, belonging to Messrs. Sir W. G. Armstrong & Co., employ between 3,000 and 4,000 workmen. They are situated on the banks of the river Tyne, having a river frontage of nearly three-quarters of a mile in length, being bounded on the other side by a main line of railways, branches from which extend into the works. They are thus in immediate communication with the entire railway system of England, and can also ship their products direct to all parts of the world.

The workshops and works occupy an area of about 40 acres. Steam engines of a total power 2,000-horse power are employed in the works in addition to three small locomotives, and the total consumption of fuel for all purposes reaches 300 tons per day. The workshops are amply fitted out with a collection of machine tools, which embrace some of the most powerful lathes, slotting, planing, and boring machines yet made, in addition to a large assortment of tools specially designed for the manufacture of rifled ordnance on Sir William Armstrong's coil system. A new forge shop of unusual dimensions has just been completed: it is fitted with the most powerful steam hammer yet made in England

and with four powerful hydraulic cranes, and is designed to meet the requirements of the manufacture of ordnance up to 100 tons weight. Arrangements are also being made by the erection of a new wharf fitted with a set of sheers capable of lifting weights of 80 tons for the loading or discharging of pieces of machinery, ordnance, or forgings of the heaviest description.

The following are the principal manufactures of this establishment;—

I. Hydraulic machinery of all descriptions, such as lifting cranes and waists for wharves, railway warehouses, docks, &c. Amongst the chief work of this class may be noted, the 100 tons crane erected at Barrow Docks, the 80 ton cranes in course of erection at Woolwich and Newcastle. The coal-discharging plant erected for Messrs. Cory & Co. in London, where the screw colliers are discharged, and the cranes and other hydraulic appliances at the St. Pancras goods station of the Midland Railway in London.

This hydraulic machinery is in use at nearly every large railway station in England, Ireland, and Scotland, and at the various docks in London, Liverpool, Hull, Grimsby, Newport, Cardiff, Swansea. It has formed the exclusive speciality of the firm ever since the first introduction of the hydraulic system by Sir W. G. Armstrong.

II. Steam boilers and steam engines of all sizes for pumping and other purposes.

III. All kinds of wrought-iron bridge work and especially hydraulic swing bridges. Amongst the latter may be noted the railway bridge over the river Ouse near Hull, with two opening spans of 100 feet each, and the new swing bridge in course of erection over the river Tyne at Newcastle, of which the swinging portion weighs upwards of 1,500 tons.

IV. Wrought-iron rifled ordnance on Sir W. G. Armstrong's coil system of all sizes from field guns to heavy ordnance of 80 tons weight per gun. Guns manufactured by the firm have been supplied to the British Government, both for the army and navy, and also to almost every other government in the world.

V. Gun carriages and arrangements of every kind for mounting guns of all calibres, whether for land or naval defences, including the recently introduced arrangements for working and loading heavy guns by hydraulic machinery, now being applied in Her Majesty's Navy, and also for other powers.

VI. All descriptions of ammunition including shot and shell of various kinds. Palliser chilled projectiles for penetrating armour plates, fuses of various descriptions, friction tubes, magazine fittings. The firm also supply "pebble" and R.L.G. powder made to the specification of, and subject to the tests imposed by Her Majesty's Government, also small arms, and all fittings required for the complete equipment of ships of war.

VII. They also supply gun boats of the "Staunch" class, designed and introduced by Mr. Geo. Kendal, complete with all their equipment.

VIII. Mechanical and electrical torpedoes, and also the apparatus connected therewith, including complete plans for the defence of harbours, river entrances, straits, &c.

IX. Gattling guns or mitrailleuses and their special ammunition.

X. Cast iron of a high quality known as the "Ridsdale" and "B. Ridsdale" pig iron, also pig iron for the manufacture of Bessemer steel. The "Ridsdale" and "B. Ridsdale" pig irons are largely used at Woolwich for manufacture of armour piercing projectiles and other purposes. They are also used in the manufacture of bars and plates of a quality equal to the best Yorkshire brands.

The foundry is capable of turning out castings of the largest size such as cylinders and framings for marine engines, columns, girders, pipes, and general foundry work. The forge is capable of producing marine engine and screw shafts of the largest size, and all descriptions of forged work. The ordnance works are capable of turning out from 60 to 80 tons of finished guns every week.

The collection of artillery embraced—

(1.) One 10-inch 18-ton M.L.R. gun, mounted on wrought-iron carriage and slide.

(2.) One 9·27-inches (9 inches Prussian) B.L. rifled gun, with Krupp-Broadwell breech-closing arrangement, also mounted on wrought-iron carriage and slide.

(3.) One 7-inch B.L. rifled gun, unmounted.

(4.) One 6·3-inch rifled Palliser gun, on wrought-iron carriage.

(5.) One 16-pr. M.L.R. field gun, with wrought-iron field carriage and limber.

(6.) One 12-pr. B.L.R. field gun, with wrought-iron field carriage and limber.

(7.) One 9-pr. M.L.R. field gun, with wooden field carriage and limber.

The 10-inch 18-ton gun has an interior tube of cast steel, strengthened with coiled wrought-iron hoops and trunnion; it fires a charge of 70 lbs. of "pebble" powder, and a projectile weighing 400 lbs.; the initial velocity with this charge is 1,365 feet, and the total energy of the projectile 5,160 foot-tons, or 165·6 foot-tons per inch of shot's circumference. By the introduction of "pebble" instead of R. L. G. powder the velocity of the projectile has been raised from 1,298 t 1,365 feet per second, and its total energy from, 4,676 foo - tons to 5,160 foot-tons, while at the same time the pressure of the powder gases or the strain on the gun has been considerably reduced. It pierces at 200 yards range an armour plate 12 inches in thickness supported on an oak backing 18 inches in thickness.

The carriage and slide are constructed entirely of wrought iron. The gun is elevated or depressed by means of two wrought-iron curved racks attached one to each side of the gun, the pinions working in these racks are fixed to the sides of the carriage, and are worked by a worm and worm-wheel gearing. The raising or lowering of the breech is readily performed by two men, one standing on each side of the carriage. The carriage is fitted with 4 gun-metal wheels or rollers, the hinder pair being mounted on excentric axles, so that the carriage runs on the four wheels when it is to be moved forward, but has to slide back upon the top surface of the slide when fired, so as to aid in checking the recoil. The slide is very strong and massive, all its parts being of wrought iron; it is mounted on four wrought-iron wheels or trucks, which are so arranged that the slide traverses upon its racers round an imaginary pivot, without requiring any fixed pivot or pivot bars. The traversing gear can be worked easily by two men, and is arranged so that by throwing out a clutch it may be used at pleasure for "running in" the gun and carriage. The recoil of the gun is taken up by one of Colonel Clerk's hydraulic compressors. The whole is manufactured with the greatest care and accuracy. This gun and carrage are throughout of the British service pattern; the carriage and slide exhibited are one of a number of sets made by Messrs. Sir W. G. Armstrong & Company for the British Government, all the parts of which are interchangeable. The weight of the carriage and slide complete is about 10 tons.

The 9·27 inch (English) breech-loading rifled gun is made exactly of the same dimensions and weight as the 9-inch (Prussian) Krupp gun. It fires a charge 51 lbs. prismatic powder, and the projectiles vary according to their description, from 280 to 310 lbs. This gun was made in

1870 for the Austrian Government, and is lent by them to the manufacturers for exhibition; it has already fired a considerable number of rounds with full charges, and is still in perfect condition. The results obtained as to range, accuracy, and velocity are, of course, the same as those of the Krupp 9-inch gun, while its cost, on account of its cheaper construction, is about 30 per cent. less.

The carriage and slide for this gun are of Messrs. Sir W. G. Armstrong & Company's own design, and are simpler than the Government pattern exhibited with the 10-inch gun.

The carriage in this case rests always upon eight flanged wheels, the plate or friction compressor employed being sufficiently powerful to take up the whole force of the recoil. The carriage is fitted with a simple appliance for making the compressor self-acting in case the man in charge should neglect to put it on. The compressor is also capable of adjustment to any required amount of tightness. In this case, also, the four wheels upon which the slide rests are so arranged that the slide traverses on its racers without the need of a pivot or pivot bars. The "training" gear is distinct from the "running-in" gear, is of a very simple nature, acts upon the front and back wheels, and is very easily worked by two men.

The "running-in" gear is that known as "Cunningham's;" it is extremely simple, and has the advantage that it can be applied to training the gun by means of side tackles in case of any damage to the training gear.

The carriage and slide altogether are of a very neat and substantial construction. The weight of the carriage and slide is about 8 tons.

This design has been copied by almost every European power, even in its smallest details.

The 7-inch breech-loading rifled gun is not mounted on any carriage; it is exhibited merely to show some improvements introduced by Messrs. Sir W. G. Armstrong & Company in the system of breech-closing adopted in the French marine. These improvements consist, 1st, in a safety arrangement which keeps the vent closed until the breech plug is fully secured, and also prevents the breech from being opened until the friction tube is withdrawn and the vent closed; 2nd, the breech-plug after being withdrawn is moved to one side on a slide instead of by a hinge, and at the same time the loading cylinder, which is secured to the slide, is brought forward into the position for loading. By this

arrangement the breech mechanism is better protected, as it does not project beyond the diameter of the breech, and the lifting on and off of the loading cylinder every time the gun is fired is dispensed with.

The cartridge is fitted with a gas-check composed of a papier maché cup strengthened by two plates of thin brass.—This arrangement has been tested by firing heavy charges, and has invariably given excellent results.

All the above-mentioned guns are constructed upon Sir W. G. Armstrong's principle of strengthening an internal steel tube with coiled wrought-iron hoops shrunk upon it.

To illustrate the manufacture, two of the coils employed in the construction of a 9-inch gun are exhibited; the one illustrating the first operation shows an iron bar 7 inches by 5½ inches, about 70 feet in length coiled in a close spiral 32½ inches in diameter outside and ready for being welded up; the other coil shows a similar spiral after the processes of welding, boring, and turning have been completed, in a state ready to be shrunk on to the steel barrel. The outside of this coil has been stained with acid, and shows very clearly the direction of the longitudinal fibres of the iron, and the lines of junction of the several coils of the spiral; the interior surface is bored and polished and shows the perfection to which the welding has been brought by the great experience the manufacturers have had. Guns built upon this system can never burst explosively and are much more reliable than guns composed wholly of steel. They are capable of firing the heaviest charges that can be consumed in the bore of the gun and have been more extensively tested in every calibre, up to that of the 12-inch 35-ton gun, than any guns of any other system of construction. As an instance of their remarkable strength and endurance, the case is cited of the 10-inch 18-ton gun used by the "committee on explosives," in their experiments on various kinds of powder. This gun was pierced in 21 places for the insertion of the crusher gauges, and although thus weakened, it fired several hundred rounds with heavy charges of various kinds of powder many of them being of a very "*brisante*" nature. It then fired an experimental series of 32 rounds, the charge being 70 lbs. of powder and the weight of the projectiles being respectively 400 lbs., 450 lbs., 500 lbs., 550 lbs., 600 lbs., 800 lbs., 1,000 lbs., 1,200 lbs., four rounds being fired with each weight of projectile. After this severe test the gun was bored out to 11 inches diameter, and re-rifled, and a similar series of 32 rounds was then

fired from the gun, the weights of the projectiles being as before from 400 lbs. to 1,200 lbs., but the powder charge being in every case 85 lbs., instead of 70 lbs.

The Armstrong construction is equally applicable to the manufacture of breech-loading as of muzzle-loading guns; and as appears from the remarks made above on the cost of the 9-inch B. L. gun exhibited, as compared with a Krupp gun of the same calibre and weight, with a very important advantage on the item of first cost. The manufacturers further state that they are prepared to give the fullest guarantee of the endurance and soundness of all breech-loading guns constructed by them.

The Palliser gun exhibited is a 32-pr. 58-cwt. cast-iron smooth-bore gun of the old system, transformed into a 64-pr. (6·3 inches calibre) rifled gun by being bored out, and having a coiled wrought-iron barrel forced into the interior, thus forming a lining to the cast-iron. Guns transformed on this system have given very remarkable results as endurance and though not suited for penetrating armour plates, they are very useful for mounting on the land fronts of fortifications, or in any positions where they are not required to act against armour plated defences. The economy resulting from this utilisation of the old material both of guns and carriages, (as the old carriage is still useful after the gun has been converted) makes this system well worthy the attention of powers possessing any number of cast-iron smooth bore guns. The charge of the gun exhibited is 8 lbs. powder and a projectile 64 lbs. weight.

Under the field artillery the first object to be noticed is the 16-pr. M. L. rifled field gun, the latest type introduced into the British service. The gun weighs 1,353 lbs. has a bore 3¾ inches (92 mm.) the charge 3 lbs. and the weight of the projectile 16 lbs. The rifling is three-grooved and the form of the grooves is similar to that adopted in the 9-pr. gun or very nearly that of the French gun corresponding to it. The carriage is of wrought-iron and both it and the limber are of the British service pattern, and are fitted with a complete assortment of munitions and full camp equipment. The weight of the gun carriage and limber in travelling order, and carrying 28 rounds is 40 cwt. 30 qrs.

The chief novelty in the carriage is in the elevating; in which the ordinary screw and nut are replaced by a curved wrought-iron rack and pinion, a binding screw is also added, which enables the pointsman instantly to fix the gun, so soon as he has obtained the desired elevation. The wheels of this carriage and limber are all alike and interchangeable; they

are of wood with gun-metal naves, known as the Madras pattern, and are remarkable for their solidity and the facilities for repair. The same remarks apply to the wheels on the other field carriages and limbers exhibited.

12-PR. BREECH-LOADING RIFLED FIELD GUN.

This is an example of the original Armstrong breech-loaders which still form the chief armament of the British artillery, and, as breech-loaders, are yet unsurpassed for simplicity, accuracy, and endurance. The carriage is of wrought-iron, similar in construction to that of the 16-pr. and fitted with the same description of elevating gear.

Both it and the limber are of the British service pattern and complete with all munitions and equipments. The weight of the gun is 919 lbs.; the bore 3 inches (75 mm.), the charge of powder 1½ lbs., weight of projectile 12 lbs., the projectiles are lead coated, and rifling is poly-grooved. The weight of gun carriage and limber in travelling order and carrying 34 rounds is 36 cwt. 3 qrs. 18 lbs.

9-PR. MUZZLE-LOADING RIFLED FIELD GUN.

This gun is made of steel and wrought iron and has taken the place of the bronze guns lately supplied to the Indian army. The weight of the gun is 937 lbs., the bore 3 inches, the charge of powder 1¼ lbs., and the projectile weighs 9 lbs. This gun is mounted on a limber carriage; the limber is similar to that of the 12-pr. B.L. The carriage is fitted with the improved elevating motion, and all the wheels are of the Madras pattern. The weight of the service 9-pr. gun carriage and limber in travelling order and carrying 34 rounds is 35 cwt. 1 qr. 13 lbs.

Gatling guns.

Messrs. Sir W. G. Armstrong and Co., also manufacture and exhibit Gatling guns or Mitrailleurs. They exhibit two sizes, one of 45-inch calibre as manufactured for the British War and Naval Departments only. The construction of the two guns is precisely similar, the difference being only in dimensions. The arrangement consists of ten barrels mounted round a central axis. A feeding drum drops the cartridges one by one into each breech as the revolution of the barrels brings it under the feeding hole, the cartridge is then gradually pushed forward by the lock cylinder which closes the breech and also contains the firing arrangements. As soon as the cartridge is forced home the stud which presses back the striker against a spiral spring is released and the cartridge is fired, the empty case is then gradually withdrawn, and by the time an entire revolution has been

completed each of the ten barrels has been fired, and the same series of movements of filling, pushing forward, firing, and withdrawing the cartridges continues without intermission, as long as the operator continues to turn the handle and there is a supply of cartridges in the drum.

These guns have been fully tried at Shoeburyness and made good practice to 1,300 yards range. A self-acting lateral movement is attached by which the bullets can be made to spread like a fan to right and left, the amount of "spread" being variable at pleasure. There is also a very neat arrangement by which a defective lock may be withdrawn and replaced by a new one in a couple of minutes. These guns are not designed to supersede or to interfere with the employment of field artillery, but they are specially valuable for defending sheltered or narrow positions, for street fighting, for sweeping the decks of an enemy's ship, or for pouring a continuous fire into portholes or embrasures, so as to hinder the working of heavy guns. The guns exhibited are mounted on carriages having the same width of track as the ordinary field artillery, but it is worthy of consideration whether it would not be preferable to make the gauge much narrower, so as to permit of their being taken through the door of a house or into confined spaces. Messrs. Sir W. G. Armstrong and Co. are now making a still smaller mitrailleur of this description, it has eight barrels, 0·45 inch calibre and weighs only 150 lbs. It is intended more especially for mountain warfare, and to be transported on the backs of mules or camels. The larger calibre 65, offers so few advantages as to range and penetration, while it has so manifest disadvantages on the score of the increased weight of the gun and its ammunition that it is probable it will be abandoned in favour of the smaller size, and only one calibre be used for both services.

Sir W. G. Armstrong & Co. also manufacture torpedoes and undertake the preparation of complete plans and arrangements for coast and harbour defences.

Torpedoes. They exhibit two systems of torpedo arrangements, one known as "Abel's" system, which is so arranged that the torpedoes may be rendered inactive, thus allowing friendly vessels to pass, or they can be instantly put in complete communication by the operator, in which case the torpedo is fired, either by contact or by operating at pleasure, and signals its number on exploding to the observing station. The other system is that known as the "Chatham" system, and is fitted with an elaborate test table and indicator for 15 mines, by which the state of the communication with any of the mines may be ascertained, or the mine fired at

pleasure. Specimens are shown of "floating" and deep sea torpedoes to contain 100 lbs. and 500 lbs. of gun cotton respectively. A model is also exhibited of the "Staunch" gunboat. This useful class of gunboat was designed and introduced by Mr. Kendal of the firm of Sir W. G. Armstrong & Co., and has since been pretty extensively adopted by the English and other governments. They are built to carry one large gun of 9 or 10 inches calibre, and are very useful for the defence of harbours, rivers, or smaller situations. They are capable of attacking the most powerful iron-clads afloat, while from the light draught they can shelter where larger vessels cannot approach them, and by their speed and small size they are well protected from attack. "Staunch gunboat.

Whatever confidence may be felt by the firm in the excellence of all the guns exhibited by them, it cannot be otherwise than gratifying to hear that a well-known Austrian officer of very high standing, and than whom no one in Europe can speak with greater authority, informed me that in his opinion the system adopted in the construction of these guns is nearer perfection than any other. The Diploma of Honour was awarded to Sir W. Armstrong & Co.

The only other English exhibitor of guns was Messrs. J. Vavasseur & Co. of the London Ordnance Works, Bear Lane, Southwark, London. Vavasseur & Co.

Messrs. J. Vavasseur & Co. are successors to the late Captain Blakely, R.A., who established a gun foundry at Bear Lane, Southwark. The material used in the construction of their guns is Firth's steel. There is an inner tube of steel tempered in oil, and this is strengthened by cylinders of the same metal shrunk on, the exterior one having a rather greater tension than the others, in order that the limit to which the gun may be tested should not be exceeded, it being apparent through the opening of the metal on the surface when that limit has been reached.

The 7-inch muzzle-loading gun at the Vienna Exhibition may be regarded as the type of the Vavasseur guns with the slight exception that the trunnion piece in this instance is of wrought iron, whereas steel is now used throughout. Its dimensions are as follows:—

Length	3,251 mm.
Length of bore	2,820 „
Calibre	178 „
Thickness of metal at breech	222 „
Thickness of metal at muzzle	63 „
Weight of gun	5,143 kilos.

The system of rifling adopted is the 'Rib' system; the grooves, three in number, being made in the projectile instead of on the gun, and the following are the advantages claimed by the makers:—Greater resistance in the piece; increased facilities for cleaning; decrease of windage, and less damage from the powder scoring the inner surface. The projectiles, moreover, are cheaper than those furnished with studs, they are more easily packed, and are less liable to damage in transport.

This gun was tried at Portsmouth by the English Government, and at Hyères by the French in 1872. It has fired up to now 225 shots without the minutest flaw being perceptible with a 10 lb. charge of L. G. powder.

The initial velocity of the projectile is 430 metres, and it is said that by using pebble powder this might be increased to 460 or 470 metres. It may be here remarked that the Vavasseur guns tried at Bourges in 1873 by the French Government were highly spoken of ("Revue d'Artillerie" of October, 1873).

The torpedoes manufactured by this firm are of the Harvey and McEvoy patterns; the following types of the latter were exhibited:—

1. A stationary torpedo made of copper, capable of containing 60 lbs. of powder, the electric contact being made by means of mercury. This self-acting torpedo which has a floatation of 70 lbs. is placed in rivers or ports at a certain depth below the water, and is connected with the shore by an electric cable. When struck by a ship, an electric current is set up and the mine explodes. This torpedo is unaffected by wave action.

2. A torpedo like the last, in which electrical contact is made by means of weight. This remains vertical so long as the torpedo is subject only to the action of the waves; but when struck by a ship the weight is forced into a different position, and, by closing the electrical circuit, explodes the torpedo.

3. A stationary mechanical torpedo intended for the defence of ports, and entirely self-acting. At the moment it is struck, the fall of a cast-iron lid on the top pulls a friction tube by means of a chain and thus ignites the charge.

4. A "drifting" torpedo for river service. It is furnished with a wheel with fans, which, so long as the torpedo drifts with the stream, do not move; but when it is checked

by an obstacle the wheel begins to turn, and sets free a hammer which, falling on the fuze, ignites the charge. This torpedo is designed for use against ships at anchor, bridges of boats, obstacles placed in a river way, and would be carried by armies in the field.

5. An electro-contact mine, containing 50 lbs. of powder. It is placed at the end of a long spar fixed in the bows of an attacking boat. When it strikes a ship below the water line the current is closed and the torpedo explodes.

Further were exhibited:—

6. A disjunctor cutting off the communication between the battery and the torpedoes which have been exploded, and at the same time showing the number of mines which have gone off. This instrument is in connexion with the battery and a group of seven torpedoes. When these mines are arranged for explosion, all the markers indicate "set." As soon as a torpedo explodes, the pointer shows "fired." At the same time the current from the battery along its line is cut off, and loss of electricity thus avoided.

7. A collection of metal and vulcanised india rubber junctions for cables and conductors, which, obviating the necessity for the soldered splicing of the cables—always a long and difficult operation in open boats, and being ready beforehand—do away with the necessity of a fire.

8. Waterproof fuzes of sorts; both chemical and platinum wire. The firm claims that all these torpedoes and apparatus are made with the latest improvements, and combine with the greatest simplicity and cheapness, absolute certainty of action.

Henry of Edinburgh.

The medal for progress was awarded them by the Jury. Military breech-loaders were exhibited by Alexander Henry of Edinburgh,—guns on his well-known system. The "Henry" Rifle Barrel Company, showed some extremely well turned out military rifles, and this was recognised by the Jury, and though they only gave an "honorable mention" yet it was in the face of the fact that the firm is only just established; machinery to give employment to 500 men being only then in course of construction. Should the rifles shown by this firm be fair specimens of the work to be turned out in the future, they will have no reason to be disappointed at the award at any future exhibition.

Soper rifle.

W. Soper of Reading sent one of his remarkable rifles, said to have been fired 60 times in one minute. This is not so astounding when it is known that the action of pulling

the trigger closes the breech as well, should extremely rapid fire be necessary, though the breech can be closed in the ordinary manner. This obtained a medal of merit. The only other military rifle which was looked on with an eye of favour by the Jury, was that of Theophilus Murcott of the Haymarket, London.

Mr. PAGET, C.E.

UTILIZATION OF PEAT AND PEAT LANDS.

REPORT on the UTILIZATION of PEAT and PEAT LANDS. By FREDERICK A. PAGET, ESQ., C.E., Juror of Group VII. and Delegate to Group I.; Mem. Soc. Civil Engineers of France; Corr. Mem. Soc. German Engineers, and of the Franklin Institute of Philadelphia; Mem. late Government Commission on Chain-cable and Anchor Proving Establishments, &c.

THE last Universal Exhibition, as regards its situation in the capital of Austro-Hungary, was extremely well suited for a study of the actual state of the industry of peat in its various aspects. Fuel is notoriously consumed on the greatest scale and in the largest quantities in the production of iron; in calcining the ores and fluxes; especially in the blast furnace itself—where the iron often takes up graphite to be directly utilised, in the Bessemer process, for instance; in the puddling reverberatory furnace used for the less pure products of the blast furnace; in the heating and other mill and forge furnaces. While many parts of Austria, especially the mountainous districts of Styria, Carinthia, and Carniola, are gifted with rich and extremely pure ores, suitable in the highest degree for the production of the best qualities of iron and steel, and worked from time immemorial; yet most of these deposits are situated very far from coal fields. The intensified modern production soon found itself hemmed in by the consumption of the forests, systematically protected, too, for many years back by the State. The modern improved means of communication have also greatly raised the value of the wood of forests formerly inaccessible by railway or canal. On the other hand, except in Croatia and Slavonia, peat moors are found all over the Austrian empire,—the Crown land richest in peat being probably the kingdom of Bohemia. The adaptation of peat to metallurgical purposes has thus been a problem for many years under the attention of Austrian metallurgists, and it seems to have been, at any rate partly, solved by Austria before any other country. Earnest attention has also been given to the application of peat to other purposes, and a Commission, consisting of members of the Zoological-botanical Society of Vienna, undertook some years ago, with the aid of the Government, a very complete investigation of all the peat deposits of Austria. The total annual production of peat in all Austria, excepting Galicia and Hungary, is estimated by Dr. Breitenlohner at five hundred millions of centners, having

increased five-fold during the last decade, while it is still, and is likely to be, in a state of progressive increase.

That the questions involved in the utilisation of peat and the waste tracts of land covered by peat are of national importance, is clear from the received estimate that the area in Great Britain and Ireland covered by peat is six millions of acres. Of this Ireland alone, according to Sir Robert Kane, possesses nearly four millions of acres, while many of these peat bogs are from thirty to forty feet, and some even one hundred feet, in depth.

The exhibits at Vienna relating to peat may be grouped into seven distinct classes, and this order can be adopted, necessarily, however, not with absolute strictness, in their examination:—

I. Its natural Formation and Growth.
II. Its Extraction or Winning.
III. Its Mixing and Condensation.
IV. Its Drying.
V. Its Carbonisation or Charring.
VI. The Products of its Distillation.
VII. Its Applications as a Fuel.
VIII. The Reclamation of Peat Lands.
IX. Sundry Applications of Peat.

There can be no doubt that, at such an extensive exhibition as that at Vienna, in most respects so wealthy, a birds-eye view, so to say, of the actual state of any manufacture can be obtained with comparative facility. Publicity being so fruitful to the inventor and manufacturer, a successful process, or machine, or product, was pretty certain to be represented, and even a non-appearance was instructive. We shall attempt to draw some conclusions from the data obtained with the view of applying the lessons to be learned abroad to the circumstances of our own country.

I.—The Natural Formation and Growth of Peat.

The Botany of Peat.—In the Collective Exhibition in the Pavilion of the Princes Johann Adolf and Adolf Josef zu Schwarzenberg was a most interesting *Hortus siccus* entitled:—"*Herbarium turfosæ dominii Treboniensis,*" a collection of all the plants, such as mosses, grasses, rushes, &c. and the remains of plants found in the peat of Wittingau, in Bohemia, where very extensive experiments of all kinds, some resulting in considerable works, of which we give particulars further on, have been carried on for years. The plants of this *herbarium* consisted for the most part, as is usual with peat beds, of mosses belonging to the genus *Sphagnum*. Of these it may be noted that the *Sphagnum*

latifoleum is said to be able to take up two hundred times its weight of water. This *Hortus siccus* was formed by Dr. Breitenlohner, for a long time chemist of the Archducal Chemical Factory for peat products at Chlumetz in Bohemia. Dr. Breitenlohner has made the subject of peat, from its chemical, botanical, and economical aspects, an earnest study of years; he has thought deeply, has lectured and written much on the subject. Without any special plan of his own in which he is pecuniarily interested, his well-grounded opinions are of the highest value, and we are much indebted to him for information otherwise very difficult to obtain.

The Stratification of the Deposits.— The Agricultural Society of Carniola exhibited some very interesting sections of the great peat deposit of the Laibach moorland, which has an area of 35,000 Austrian *Jochs*, or 42,665 acres. Each block was cut perpendicularly out of the moor, from the top, of recent plants and mosses, 18 inches high, to the bottom of a clay with fresh-water shells. The gradual disintegration and carbonisation of the successive four strata as the bottom of black bituminous humous matter was reached, could be plainly observed, affording an obvious lesson as to the value of, whenever possible, working up the whole vertical section in order to get an equable fuel of a quality resulting from the average section of the bog. A vertical section of any peat bog or moor always shows several stratifications differing very considerably from one another, whether chemically and physically. The material sometimes alternates from the nearly useless moss at top to an amorphous bituminous peat, scarcely inferior to lignite coal. According to Dr. Senft, the contents in carbon of peat are nearly double towards the bottom of a given deposit, and it has been stated that peat, in some rare cases, is even found entirely converted into coal. It is now generally recognised that peat, the product of a specific rotting of vegetable substances under water, is nothing else but fossil fuel in its lowest and more recent stage; and that from peat we ascend to lignite in its numerous states, to bituminous coal in its innumerable stages, up to anthracite and graphite. It is therefore natural that peat from one moor should be seldom exactly similar to that of another, whether in chemical character, or state of aggregation, or density.

"High" and "low" Peat beds.—The specimens sent from Carniola were from a "high" moor or "*Hochmoor*," or mountain peat deposit, so termed in contradistinction to the peat bogs which are found along the margins of rivers or lakes. Peat bogs not naturally drained by situation are often incapable of bearing the weight of the foot, and are of

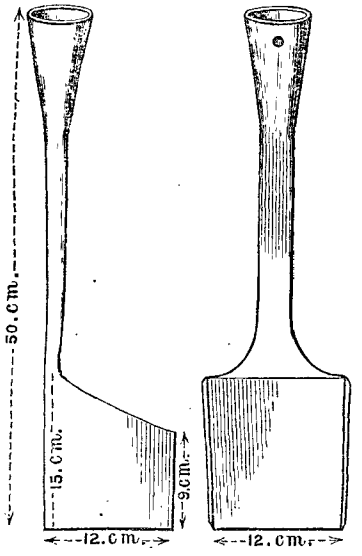
greater depth than high bogs, the peat itself being less fibrous, and showing less evident indications of its vegetable origin. High moors, situated on the slopes of a mountainous country, have less deep peat deposits, sufficiently solid to be walked upon, and the peat is more fibrous than bog peat. Briefly, a "high" peat bed is one capable of being drained by gravity; in Holland, the "low" peat beds are often drained by wind-mills.

II.—The Modes employed for the Extraction or Winning of Peat.

The modes of extracting peat from the bog or moor necessarily vary with its nature; the most generally employed on the continent simply consists in cutting or digging it up by hand labour. Even in the low bogs of Holland, the men working in water in high fishermen's boots, "feel their way "and cut the earth with their spades, seize the divided sod, "and throw it in a barge," in the adjacent canal. Inquiry shows that the plan at present used in Germany more than any other simply consists in cutting peat by hand labour, in the old and apparently very primitive way. It is thus that, in Bavaria, for instance, are worked the deposits of Natternberg, Failenbach, Freisnig, Landshut, Birkeneck, Ottershausen, Weiden, and of most other localities.

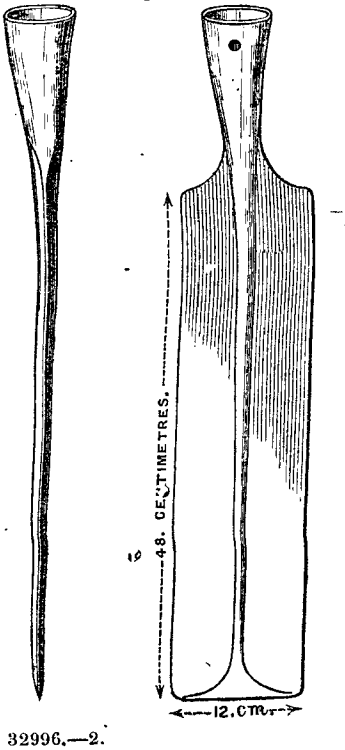
One of the most important exhibitions of peat was that from Benedicthütte near Salzburg, the well-known town in Upper Austria proper. The Salzburger Torfmoorgesellschaft possess the large glass works of Benedicthütte, at which plate glass is manufactured by the Belgian-Rheinland process; and they work for their own use a portion of a large peat deposit in the neighbourhood. Through the courtesy of Herr Kalus, the chief manager, we have been furnished with particulars additional to those given at the Exhibition. The Buehrmoos peat deposit near Salzburg covers an area of 640 Austrian *Joche*, and numerous borings testify to an average thickness of four metres. Of the 260 *hectares* or 640 English acres belonging to the Salzburger Torfmoor Gesellschaft 60 *hectares* are being worked, in order to produce annually 15 millions of bricks. This surface of 60 *hectares* is drained by three main canals, crossed at right angles by a number of parallel drains or ditches of an average depth of 2 metres,—the depth being necessarily gradually increased as the peat is worked out. This is now done almost entirely by hand labour, which is adapted to the varying requirements of the drainage and the state of aggregation of the peat itself.

Fig. 1.



With peat of medium consistency, a spade (Fig. 1.) is used having a pair of side wings cutting vertically at the same time three sides of the cube. A skilful workman can cut per diem from three to five thousand bricks 10 centimetres wide, 10 centimetres thick, and 40 centimetres long.

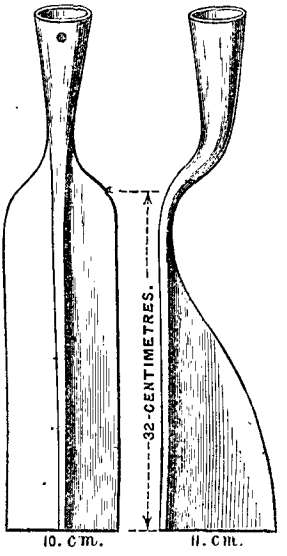
Fig. 2.



With very tough peat, a square knife-like spade (Fig. 2.) is used. The pieces are thereby very neat with sharp edges, and can be at once stacked in a way we describe more fully under "Drying." Three thousand of these bricks can be cut per diem.

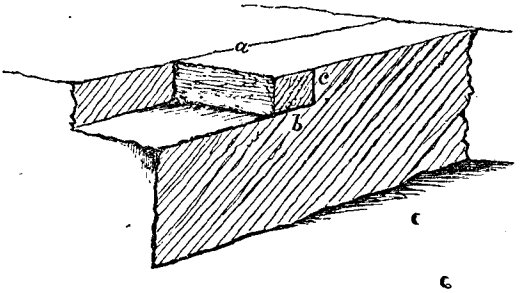
With peat not too soft, a spade (Fig. 3.) is used to which a vertical web running down the centre is welded, and like

Fig. 3. Double Slane.



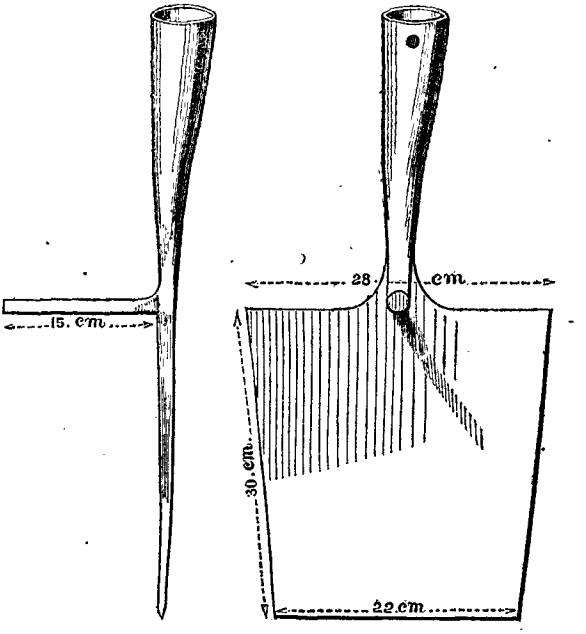
the previous knife-like spade, it is to be thrust in (*schieben*) horizontally. This tool is substantially the same as the Irish "slane," but double, as the slane, intended to cut only one thick sod at a time, has a single wing on one side of the blade only. In both these last operations a previous vertical cut, (see Fig. 4.), determining the length of the pieces, is made

Fig. 4.



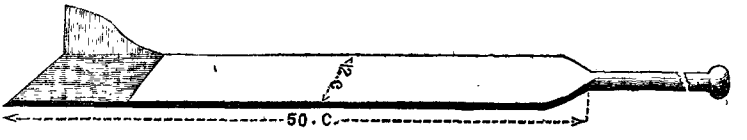
according to the line *a*; and then for each piece there is taken the horizontal cut *b* and the vertical incision *c*. With what we have termed the "double slane," these two cuts necessarily take place at the same time. The preparatory vertical cut in the sod is done by means of a flat spade knife (Fig. 5.), fitted

Fig. 5.



at the centre of its upper edge with a transverse bar determining the vertical depth. This, when it can be used, is the method most preferred, as a man can turn out 10,000 bricks per diem; and there is very little of the waste which occurs with the first tool (Fig. 1). used vertically. When the peat being dug is too soft for the application of these methods, it is struck into moulds as will be described further on.

By way of contrast to these German peat implements, we can show a sketch (Fig. 6) of a common form of the slane,



used by the Irish peasant. With this long narrow spade, twenty inches by six, having one wing at right angles, a vertical cut being first made, the "slane" then cuts the bottom and one side of the block.

Mr. McGrath informs us that in 1865 he engaged a common turf-cutter for 100 days and put him to cut peat on an Irish bog, mainly to see exactly how much could be done by hand labour, and by the use of the slane. Each day the

man worked he turned out five tons of marketable fuel, or for the 100 days 500 tons. The whole cost of cutting, &c. did not exceed 3*s.* 8*d.* per ton. This work was done without any mechanical aid.

Brosowsky's hand peat digging-machine.—This is a machine which is in pretty extensive use in some parts of Germany; and several specimens of peat were stated to have been excavated by it. Herr W. A. Brosowsky, of Jasenitz, near Stettin, has been building his peat-digger since 1842; it was probably the first of its kind, and a large number, it is stated 2,300, are now at work—principally in north-east Germany and in Poland. It seems to have been the progenitor of the French *grand louchet.* With two men this hand apparatus is stated, by Herr Brosowsky, to be able to bring up from short depths of about six feet nearly 2,000 cubic feet in twelve hours. It weighs less than one ton. It consists of a cutter, like the four sides of a box, with oblique edges, which by its own weight, and by means of a crank and rack-work, is forced down into the peat to a depth that may reach 20 feet. It can cut only at the edge of a ditch or excavation, and when it has penetrated sufficiently, a spade like blade is driven under the cutter by means of levers, and thus a mass is loosened, having a vertical length of ten feet or more, and whose other dimensions are about 24 by 28 inches. This is lifted by reversing the crank motion, and is then cut up by hand into blocks of 14 in. × 6 in. × 5 in. Each parallelopipedon of peat, cut to a depth of 10 feet, makes 144 sods. It can be used to raise peat from below the surface of the water, rendering drainage in many cases unnecessary. The Mecklenburg moors are now traversed by canals cut by this machine. It is, however, only properly applicable in rather shallow and wet moors quite free from wood and the roots of trees; being more especially of value where a thorough drainage cannot be carried out. On high bogs containing wood it cannot be used and, in any case, beyond a depth of about nine feet, this hand apparatus is only to be worked with great exertion.

As this machine is, however, in such extensive employment on the continent, and as its use would favour the working of raw peat, in which, as we consider, is to be found the true future, if there be any future, for the industry of peat in these islands, we now give a detailed description of it, mainly due to a publication by Professor Rühlmann, of Hanover, besides a lithograph showing two perspective views of the machine in operation on the bog (Fig. 1*a.* and Fig. 2*a.*), and Figures 1*b* to 4*b*, affording views to scale of a machine slightly different in detail from that in perspective and to

which the letters of our description specially refer. Figures 1*b* and 2*b* are respectively side and end elevations of the whole machine; Figures 3*b* and 4*b* are enlarged views of the cutting tool or spade; Fig. 3*b* being a side elevation, and Fig. 4*b* a plan. It consists of a square box-shaped knife, *a*, *b*, *c*, *a'*, the two cutting edges of which $a\ \alpha$, $\alpha\ \beta$ and $\beta\ \gamma$, each have a different inclination to the horizontal line. The hinder portion, *b*, *b*, of this box is fitted to the wrought-iron bar *y*, the end of which tapers to a sharp edge *y'*, by which the cutting action into the peat is so to say prepared, while offering a sort of guide into the peat mass. To the long bar *y*, *y*, is fixed a rack of wrought-iron plate, geared into by a spur wheel keyed on a short shaft B, B, revolving in bearings on a fixed carrier A, A, and turned through a hand-wheel or a hand-winch, C, C, by the operative.

During the down stroke, or when the peat has to be dug into, the weight of the bar *y*, *y*, of the rack *y*, of the cutting tool, &c. tends at first to force the tool down; this tendency has soon to be reinforced by turning the arms C, C, till at last a square prism of peat is cut out. It is to be noted, that in the space over the edge *a*, α, (Fig. 4*b*) to the left, or in the same direction in Fig. 1*b* there is no peat, this space being clear or filled with water; the knife *a*, α, β, γ, has only to cut out three sides, so that the prolongation *f* of the knife box *a*, *b*, *c*, can descend without hindering the digging of the peat in the vertical direction. In other words, the machine is only intended to work at the edge of the excavation. This front end of the cutter-box is intended to receive the broad even knife, *e*, *d*, sharpened on both sides (Fig. 3*b*). The hinder portion of this knife is adjustable sideways in grooves, and it serves to cut away the bottom of the prism of peat where it hangs to the whole mass.

The required movement is given to the knife *e*, *d*, by means of two chains *h* and *i* fixed thereto, and guided by being made to pass over long cylindrical rollers *k* and *l* fitted to the front prolongation of the cutting box. The other ends of these chains are fixed to levers *n* and *n'*, actuated from below by means of ropes *p* and *q*. It is seen that by means of a pull at the rope *p* the chain *i* is drawn up and the knife *e d* caused to cut away at the base of the column of peat. While the cutting box is being drawn up, the surface of the knife *e*, *d*, serves as a carrier for the isolated long prism of peat, while it is at the same time kept from falling sideways by means of a framing of hoop iron *m*, *m*, *m* (Fig. 1*b* and Fig. 2*b*). As soon as the block of peat has reached the surface it is cut by hand spades into sods and thrown into barrows or

small trams set on rails in order to be taken to the drying ground.

While this is being carried out the cutter-box and apparatus have to be shifted on one side to the breadth of the knife. The way this is done will be rendered clear by looking at the framing of strong wooden beams, usually forming in plan a triangular framing G, and a vertical framing of the standards G_1, G_1, and horizontal beams G_2, G_2, held together by angle iron and tied by rods P_1, Q. On the horizontal surface of the angle iron F, run rollers *t*, *u*, which belong to a second framing consisting of the vertical beams D and the horizontal beams E and E_1 well tied together by strips of plate D_1, D_1. To this second framing is fixed the carrier A, A already mentioned, so that by shifting E, D, to one or the other side, the cutter-box is similarly adjusted.

On the pin *r*, running through the top-piece E, being withdrawn, the iron-lugs *v*, *v*, being taken hold of, the working part of the machine can then be set sideways. The vertical framing G_1, G_1, is generally made of such a width that four cuts sideways can be taken. When the peat has been dug out to the whole breadth of the framing, the machine has then to be shifted backwards by the width of the knife $\alpha, \alpha, = \alpha, \beta$, (Fig. 4*b*). To be able to carry this out, the strong horizontal beams G, G, of the framing form a triangular frame in plan, lying on its longest side (Fig. 1*b*.) on two rollers K, K, which run in grooves formed in the bottom beam I, while the shorter side, the apex of the triangular basis, lies directly on the flat surface of a long fixed beam H. In the direction of the width of the machine is a lever L, one end of which can be slightly oscillated up and down on a fixed bolt L_1, while grasping it at the free end L_2, it can be pressed down on the upper edge M_1 of a vertical standard M_2, in suchwise that the part of the framing lying over H is lifted up and the whole weight put on the rollers K_1 K_1. On a second workman then moving the lever Y, Y, from left to right (Fig. 1*b*), one end of which rests on the bottom piece I, being also linked by X to G, the whole machine can then be shifted in the longitudinal direction of Fig. 1*b*. In order to fix the bottom framing G on the basis I, there are holes V, V, in the latter which adjust themselves to holes U in the beam G, in suchwise that iron pins R can be dropped into them. To facilitate this, a foot lever T is employed. S is a grooved foot-board for the workmen. Of the four men employed able to deliver daily from 1,200 to 14,000 blocks of peat, No. 1 works the digging and cutting apparatus of the machine, No. 2 helps in setting it, lifts off and cuts up

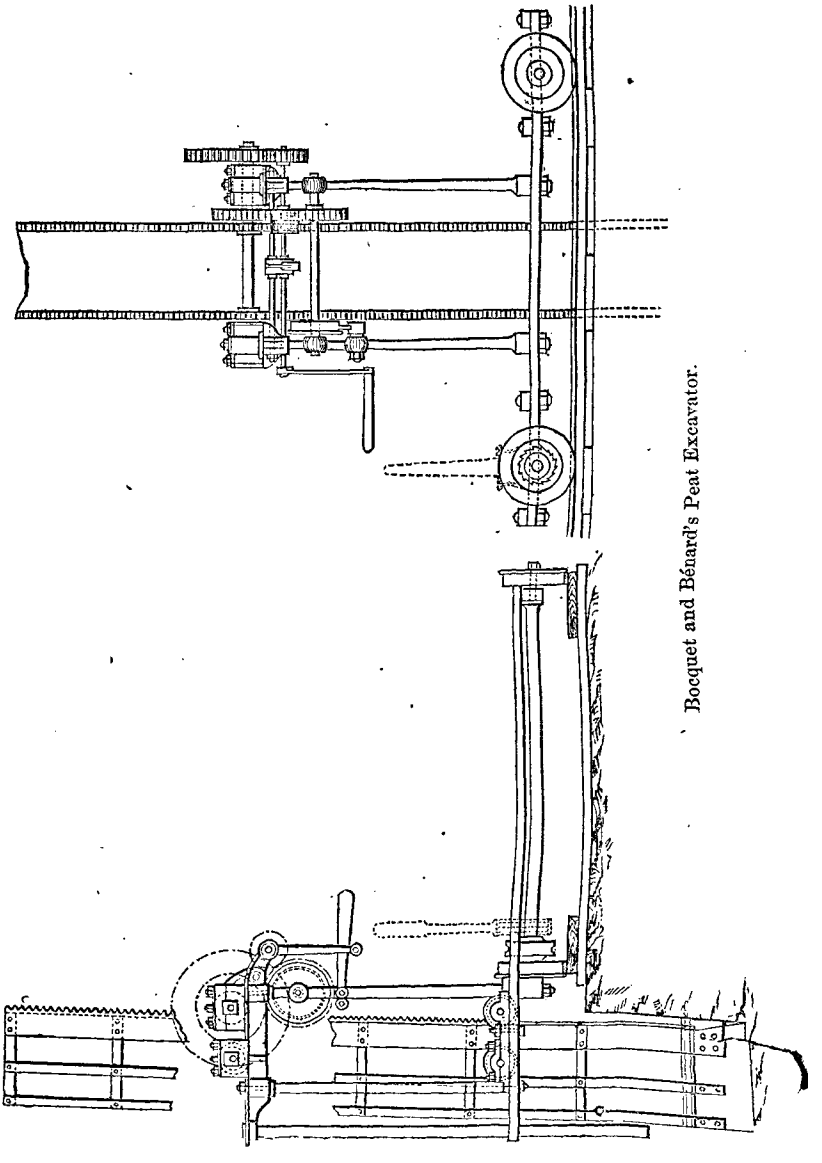
the peat, No. 3 brings the freshly dug peat on one side, while No. 4 piles up the sods.

Though Mons. Challeton de Brughat appeared in the general and French special catalogue as an exhibitor of worked peat and charcoal, none of his products arrived. It is proposed to apply this gentleman's plan on one of the Norfolk fens; and time will show whether this expensive process can take root in England. Some specimens of compressed peat and peat-charcoal, admirable in quality, but with no indications as to price, were sent by M. Balbiani and Co. of the peat works of Saussay, near Ballancourt, and by Monsieur Bocquet, of Paris, Quai de Valmy. Each exhibitor also showed a water-colour drawing, from which, however, little definite could be learnt as to the modes of procedure, apparently similar. These specimens of the French peat and peat-charcoal were very fine; but no data as to the cost and means of production were given to inquirers. Large quantities of peat are worked in France, necessarily in those departments far from coal, such as the Somme, Loire Inférieure, Pas de Calais, Oise, even in the Marne where coal is said to have been found but not worked from want of enterprise—in the Eure, Seine et Oise, and elsewhere. In Normandy, twenty years ago, we remember the circular so-called *mottes* of peat extensively used to supplement wood in open fire-places. At Rheims, and at Liancourt, on the Northern Railway, great quantities of peat are annually worked.

Bocquet and Bénard's Peat Excavator, or "Louchet."—As can be seen from our synoptical table of the different processes actually at work, a distinctive feature of the French systems apart from the more usual hand-cutting, consists in the general use of excavating machinery. The accompanying sketches on page 280, showing a side and an end elevation of MM. Bocquet and Bénard's machine, will give a general notion of this class of machinery, which is in use to a not inconsiderable extent on the moors and bogs of France.

It has a differential motion, working in both directions, and the whole apparatus may be driven either by hand or steam power.

The cutter carrier consists of an iron framing fitted with two racks, by which it is operated. The lower part forming the cutter, and to which are fixed all the vertical parts of the excavator frame, is provided with two hinged side cutters. This frame is set in motion by two guide pinions on the main shaft, while six guide rollers, two of which are placed on a level with the driving pinions, hold the frame in place side-



Bocquet and Bénard's Peat Excavator.

ways. The upward and downward motion of the excavator is imparted by a winch handle if the machine is to be driven by manual power, or by a pulley on the same shaft when

steam is employed. The shaft is rotated in the same direction for moving the frame both up and down, this being attained by the use of a double set of gearing, one set being directly operated from the pinion for raising and the other for lowering through another pinion and wheels on the rack pinion shaft. The pinions are thrown in gear alternately, according as the carrier is to move upwards or downwards, and different speeds for raising the excavator slowly and lowering it quickly are obtained by varying the relative sizes of pinions with the wheels. The shaft which carries the pinions, and also the driving pulley or winch handle are free to slide in bearings.

One of the rack pinions carries a ratchet, by which the cutting tool may be held arrested in any position when the winch handle is released, a break being employed to control the descent. Suppose the tool to be in its highest position the action is as follows:—The clutch is first disengaged from the shaft, and the latter slid in its bearings to throw one pinion out of and the other pinion into gear, after which the ratchet is released, and the tool allowed to descend under the control of the brake. Should the resistance of the peat be too great the brake may be relieved altogether, and the descent of the tool assisted by means of the winch handle. The gearing is all mounted on two frames, supported on iron columns bolted to a carriage on wheels. The brake shaft, which also carries the intermittent gearing for lowering the tool, is mounted between two of the columns, and the brake lever itself is also pivoted to one of the columns. The carriage frame on which the apparatus is mounted is formed of longitudinal and transverse bars and diagonal tie rods of iron bolted together. When the machine is to be worked by steam a vertical boiler and engine is placed on an extension of the two frames, the winch handle in this case being replaced by a driving pulley and clutch. The engine serves to balance the apparatus and the weight of material raised.

After a recent visit to Mons. Balbiani's peat works, of which particulars are given in our tabular statement, Professor O'Reilly describes as follows the peculiar excavating apparatus and other machines there employed. "The hand *louchet* presents the defect of not insuring the working of the bog to the bottom; but it is clearly to be preferred to the spade. For methodical working it is advantageously replaced by the machine *louchet* worked manually or by steam. The manually-worked *louchet* is much employed in France, is cheap of construction, costing only from 700 frs. to 900 frs., is easily handled and moved and involves no skilled labour properly so called. On

the other hand it necessarily depends on the workman for its utility. It should evidently give the best results as regards quantity produced, when worked by task work or by a party interested in the bog, but it may occasion an insufficient working in depth either on account of insufficient force to overcome the resistance presented at some one point or because there is interest to work quickly rather than well. Mr. Balbiani pointed out in his bog a place where precisely this had happened, and where, therefore, the turf is now virtually lost. The *louchet* proper is an openwork cage of wrought iron having a height of 3 in. to 6 in. (according to the depth of bog to be worked) and a horizontal section of 0·35 m. by 0·35 m. Three of the sides constitute the cage, the fourth being open so as to allow the removal of the block of turf cut by the *louchet* in its vertical movement. Attached to the face opposite the open side and its axis is a rack of such a length that the cage can be made to move through the required depth. The movement is communicated by a pinion mounted on a shaft commanded by the workman in the hand-worked machine and by a transmission from a driving shaft in the case of the steam *louchet*. The steam-worked *louchet* must necessarily give the assurance of cheap and sufficient power so as to ensure that the *louchet* be driven to the required depth as also to detach the mass of turf cut by it. It should also be remarked that when the effort to detach is made by jerks on the winch handle in the manually worked *louchet* the machinery may suffer strain, and this jerking certainly tends to break the block of turf and detach fragments which, falling back into the water, represent so much loss of product and labour. Steam power allows of this resistance being overcome at once and steadily; the mass is, therefore, raised above the water level in one condition and the least amount of turf is lost. Of course rapidity of work can be secured by increased pressure of steam, and with turf a pressure of six atmospheres was produced by Mr. Balbiani in his small vertical boiler working his *louchet*. Depth can therefore, be obtained, the whole turf taken up with certainty rapidity, and, moreover the machine may be made to follow its work by transmission, so that no time be lost in advancing the machine by hand as is at present practised. In the steam *louchet*, as at present constructed, there are four or more simple *louchets* working together, and the number to be mounted on the one frame depends rather upon the requirements of the work and the size and power of the boiler and engine, taken in conjunction with the limit of weight which the bog can sustain for a given surface, than

upon any technical difficulty of construction. There is clearly advantage in having as powerful a *louchet* as can be managed by one driver, since his pay must form an important element in the cost price. The steam *louchet* as manufactured by Mr. Celis of Amiens, without the engine and boiler, costs about 5,000 frs., and with the present prices of raw materials might cost about 5,500 frs. = 220*l.* Mr. Balbiani employs a small vertical boiler of about 3-horse power to drive the four *louchets.* Such a boiler with the cylinder attached and driving wheel for band should cost in Great Britain about 80*l.* to 100*l.*, so that the whole machine may be estimated at 300*l.* to 320*l.* The duty performed by the *louchet* was stated to be the extraction of about five cubic metres in about six to seven minutes."

"His estimated price would be for a complete machine ready for working 500*l.* = 12,500 frs. We may thus assume that the price of a quadruple steam *louchet,* capable of working to a depth of 6·00 m. and corresponding to a production of about 60 tons manufactured peat per day is between 320*l.* and 500*l.* The turf is received from the *louchet* in a flat boat holding from about five to seven tons of raw peat."

III.—The Modes Employed for Mixing and Condensing Peat.

A great number of the specimens of peat exhibited could simply be judged of as to their texture and appearance, there being no particulars given. Favourable exceptions to this rule were formed by exhibits from Prussia, of which the prices and other particulars were stated. The Royal Prussian State Forests Direction of the province of Danzig sent a number of samples of raw and manufactured peat; the lowest prices for cutting the raw peat, ranging from 5½ to 12 *silbergroschen* per cubic meter; and the selling prices respectively from 12 to 23 *silbergroschen.* One *groschen* is the tenth part of an English shilling; and there are 30 *groschen* to the Prussian *thaler.* Five private exhibitors from the same district, names not stated, showed peat in each case prepared by machinery similar to a brick press or pug mill, and worked by horses or steam power. The figures given from such an official source are necessarily of value. At Zeschin, the press, worked by one horse, and taking from 8 to 10 men, yielded peat sold per cubic meter at 30 *silbergroschen* or one *thaler,* costing for working 18 *silbergroschen;* at Klein Loebez, a Schlickeysen horse machine from Berlin is used, and the price per cubic meter is 1 *thaler*

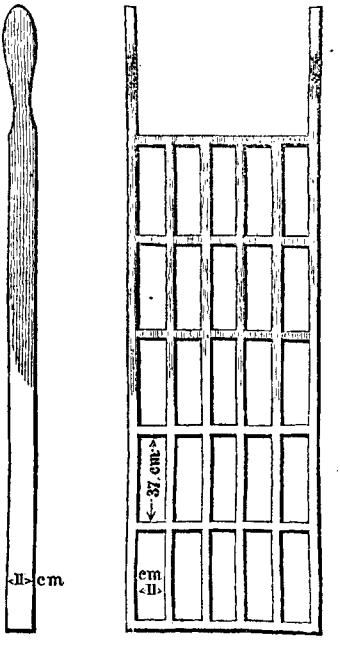
8 *sgr.*; at Roppuch, an extracting or excavating machine on Brosowski's plan is used; the peat would be sold at 1 *thaler* 25 *sgr.* per thousand bricks. At Johannisdorf, a locally made press is used, driven by an eight horse-power portable engine. Eighteen men working 12 hours per day turn out about 36,000 bricks from 4,500 centners of peat. The maximum is 70 bricks per hour. Each brick weighs thirteen zoll pounds wet, and only from 2 to 2¼ lbs. when dry. The thousand cost 1 *thaler* 14 *sgr.*, 7 *pfennige*, and are sold at 3 *thalers* 15 *sgr.* At Tigenhof the press, driven by a portable engine, delivers peat sold on the spot for 9 *thalers* 10 *sgr.* per 40 *centners*. Of the Paklidimmer peat bog in the province of Prussia proper, were shown a plan, a description, and samples of peat. Five principal kinds were there, (*a*) nearly homogeneous, is found under water, shrinks one-third of its volume, weighs dry per *festmeter* 565 *kilogrammes*; (*b*) is found above water, contains remains of plants, particularly of rushes, often wood, which is never found in (*a*), shrinks one-quarter of its volume, weighs dry 470 *kilogrammes* per *festmeter*; (*c*) is brown moss peat, shrinks one-fifth of its volume, weighs dry 310 *kilogrammes* per *festmeter*; (*d*) yellow moss peat, soft like felt, shrinks one-sixth of its volume, weighs dry 245 *kilogrammes*; (*e*) white moss peat, of the most recent formation, shrinks one-eighth of its volume, weighs dry 180 *kilogrammes*. The season for cutting the peat only lasts from eight to ten weeks on account of the long winter and the rainy autumn. The land cleared is partly used for pasture, partly for planting with birch trees. 3·3 *hectares* planted with birches 55 years ago, gave 210 *festmeters* of timber per *hectare*; or 8·4 *festmeters* per *hectare* per annum. From the Carolinenhorster peat moor near Stettin, were also samples, tools, and a description. Its thickness ranges from 0·5 to 5 meters, and it is worked on the plan "generally adopted in East Friesland," according to which the peat is cut away in stages or terraces, and the stacking and drying of the sods take place close to the cuttings. The dark heavy peat, (*a*) weighing 250 *kilogrammes* per cubic meter, is sold for 18 *silbergroschen*; (*b*) a lighter kind, mixed with mosses, weighing 193 *kgr.* per cubic meter, is sold for 14 *sgr.* per cubic meter; (*c*) brown moss peat, 11 *sgr.* per cubic meter of 152 *kgr.*; and (*d*) white moss peat, 9 *sgr.* per 152 *kgr.* a cubic meter. The net returns during the last 10 years have been 23·1 *thalers* per *hectare*. The Baltic Society for the encouragement of agriculture, Eldena, Pommerania, sent a number of samples, principally of raw peat, forming a collective exhibition of nine separate senders; the specimens

being mainly from the Gruenlands moor. Particulars were not given. The places in the district (*Kreis*) of Strassburg, known as Kurzenhausen, Killstedt, and Weyersheim, sent specimens of earthy peat roughly moulded, and stated to be applicable under steam boilers and in house stoves. It was said to contain much ash. The superior peat of the Hochfeld and of the Hochvogesen is not much worked in Elsass-Lothringen as it is too much out of the way.

Difficulty in obtaining a fixed standard in comparing peat. —If particulars such as the above had been given by all exhibitors with the same method as by the Prussians, the general review they afforded would have been of greater value. At the same time, much confusion, and a confusion difficult to avoid, exists on this subject. At first sight, the weight of peat appears the best mode of estimating the quantity. But then peat always contains such a large proportion of moisture that unless the amount of dryness be defined, a matter injurious to combustion is reckoned and paid for as fuel. For instance, the bricks at Johannisdorf are expressly stated to weigh 13 pounds wet, and only from 2 to $2\frac{1}{4}$ lbs. when dry. Some of the Prussian exhibitors, as noticed above, properly draw a distinction between a *Raummeter*, or what may be termed a nominal cubic meter, and a *Festmeter*, or an actual cubic meter, in which no empty unfilled spaces are left between the bricks. That great confusion may arise from this mode of estimation results from the observations of Herr Wasserzieher, who found that, if a number of blocks of peat be put into a box and shaken together, the total cubic contents of the empty spaces between the blocks may amount to 46 per cent. of the whole; and even when closely packed, to 30 per cent. of the whole. Here is a very wide margin for error. These objections apply with intensified force to an estimation by number of bricks; so that the figures and prices given must be taken with many qualifications, and have only a relative value. As regards turning them into English money, it must be borne in mind that the value of money and of capital is still much greater on the continent than in Great Britain; and that labour is cheaper; though, no doubt, of late years, there has been an increasing tendency to approximation. It is therefore clear that all such figures must be received with great caution.

In the building devoted to so-called "additional exhibits" was a collection of specimens of peat from different parts of Austria, stated to have been sent by Dr. Breitenlohner. Specimens of moss, fibrous, and ball peat were sent by the Radmeister *Communität*, Vordernberg, Styria; as also

peat from Schrams in Lower Austria, out of a Schlickeysen machine; from Görkau in Bohemia, out of a Seydel machine; from Admont in Styria, out of a machine by Müller in Prague; and some turf in balls of from 1½ to 2 in. in diameter, known in Austria under the term of *Kugeltorf*. This, literally "ball-peat," is nearly equivalent to the "hand-turf," or "foot-turf," or the "stone-turf" of Ireland. Made from black peat from the bottom of the bog first "footed" into "mud," it is shaped with the hand, and obtains much consistency when dried. In the large pavilion filled by the Ministry for Agriculture and of the Forests of the state, were some bricks of raw peat from Goldenhöhe, in Bohemia. Oblong pieces were to be seen in the *Collectivausstellung* of the Styrian forest products; and similar specimens by Herr Lohninger, of Miedling. From the Tyrol was sent some compressed peat, by Herr Gottlieb Schaber. Several Italian exhibitors showed very inferior looking bricks formed of peaty mud or matter dredged up from the lagoons of Venice. Amongst these was Signor Bonaventura Segatti, of Portogruaro, Venice; Peter Qugliati, of Chioggia, Venice. Raw peat from a high bog—*torba di monte*,—was also sent from Italy with samples of iron, but its exact derivation could not be ascertained. Compressed peat, of an apparently good quality, was sent by Signori Cirlza, Cramer and Co., of Turin. In the Austrian *Kohlenhof* Signor Gualiati, of Trieste, showed raw peat from the Venetian lagoons; also compressed and carbonized peat. In the Russian department of the main building, the Charkowsche Model Farm exhibited a solid block of hand-cut peat three feet high by sixteen inches cross section.



After describing the mode adopted for winning peat at the Benedicthütte, near Salzburg, we stated that peat too soft to be cut is there subjected to the process of moulding (*Modeln*). A very good product results, but it is much dearer than by the other plans. The *Model*, as shown in the

annexed cut, simply consists of a wooden frame of square moulds, open at top and bottom. The peat, well worked into pulp, is struck or filled in, upon which the set of squares is lifted up, removed to another place, and so on. This plan requires a very level drying surface, and by it one man with from two to three underhands cannot produce more than from three to four thousand bricks per day. This form of hand brick mould is common in the peat works of Austria and Southern Germany; it sometimes is made with spaces for only twenty-four bricks.

In order to show the degree of density which could be attained by the peat of Benedicthütte, several pieces were exhibited which, after being planed, were polished like ebony. These cubes were made from peat pulp. The largest cube of about one foot (0·0316 cubic metre) of massive peat weighed 26·32 *kilogrammes;* the smaller cube, containing three-tenths of a cubic foot of peat, 9 *kilogrammes.* Nevertheless, machine or compressed peat has been lately given up by the Salzburger Gesellschaft, as they found it too dear for their own use, as compared with hand-cut raw peat. A peat press, by Schlickeysen of Berlin, driven by a ten-horse portable engine was employed at Benedicthütte. The raw peat was conveyed on small cars by a wire rope worked by the engine into the cylinder of the machine. The central rotating axis in the cylinder, fitted with wings forming a screw surface, macerated the peat and propelled it out of several hexagonal mouth-pieces in lengths which, being cut into pieces by wires, were conveyed on planks and trucks to the drying shed. Although the quality of the compressed peat was found superior, Herr Kalus the manager, yet considers "that this process will never be applicable on a large scale." "Portable machines, capable of being easily and quickly set "to work in the field, and of being easily removed, have but "a small yield. Their construction is made too slight to "enable them to turn out large quantities of macerated peat. "On the other hand stationary machines, while sufficiently "powerful to do much work, do this work too expensively, "on account of the cost of transport to the drying sheds, "which cost is in course of continuous progressive increase "as the work proceeds. Properly directed hand labour can "produce good peat at a cheaper rate than machinery. All "the known machines driven by steam have so many ob-"jections that they cannot compete with human labour "which, if dearer, can yet be shifted about from place to "place and adapted to the varying conditions of the work "and of the seasons with perfect facility."

These opinions are necessarily of weight, having been the result of much experience. In some parts of the continent, as in Hungary, a family of gipsies, father, mother and children of various ages, in association, and with a system of division of labour formed by practice, are often seen to beat in economy of production, all items reckoned up, the most modern English brickmaking machine. So with working peat on not too large a scale. On the other hand—as the drawbacks to the use of raw peat especially consist in its large volume, its unequal quality, and the considerable losses attending its transport for the supply of towns far from coal—concentrated peat, produced in the immediate neighbourhood, can find a market, on account of its greater density, heating capability and other advantages.

A simple process, sometimes termed in Germany and Sweden the "Hanoverian" is also largely employed in Holland and in Russia. The best fibrous peat is taken, and wheeled on to a hard flat surface on the field, where it is well kneaded and stamped down with the feet of men provided with wooden shoes the soles of which have been oiled or tarred. In this way the mass is gone over several times, and also beaten down by a sort of mallet, until it becomes a hard and compact cake. It is thus left for several days, when it is cut up into square blocks, and then into the smaller bricks. It was also attempted at Geestemuende to adapt a brick press to this, in order to obtain bricks, but this addition made the process too costly, and it has been given up for some years. The peat worked in this way by treading is termed *Backtorf* in Austria and Germany. "*Backen*," in German, as applied to coal, means that it "cakes" or "packs" itself together in the fire, so that *Backtorf* may be translated as "caked-peat."

In Denmark, as also in some parts of Ireland, the same operation on peat is carried out by horses' hoofs. Horses are driven round in a ring, and the trodden peat is kneaded into balls by women and children.

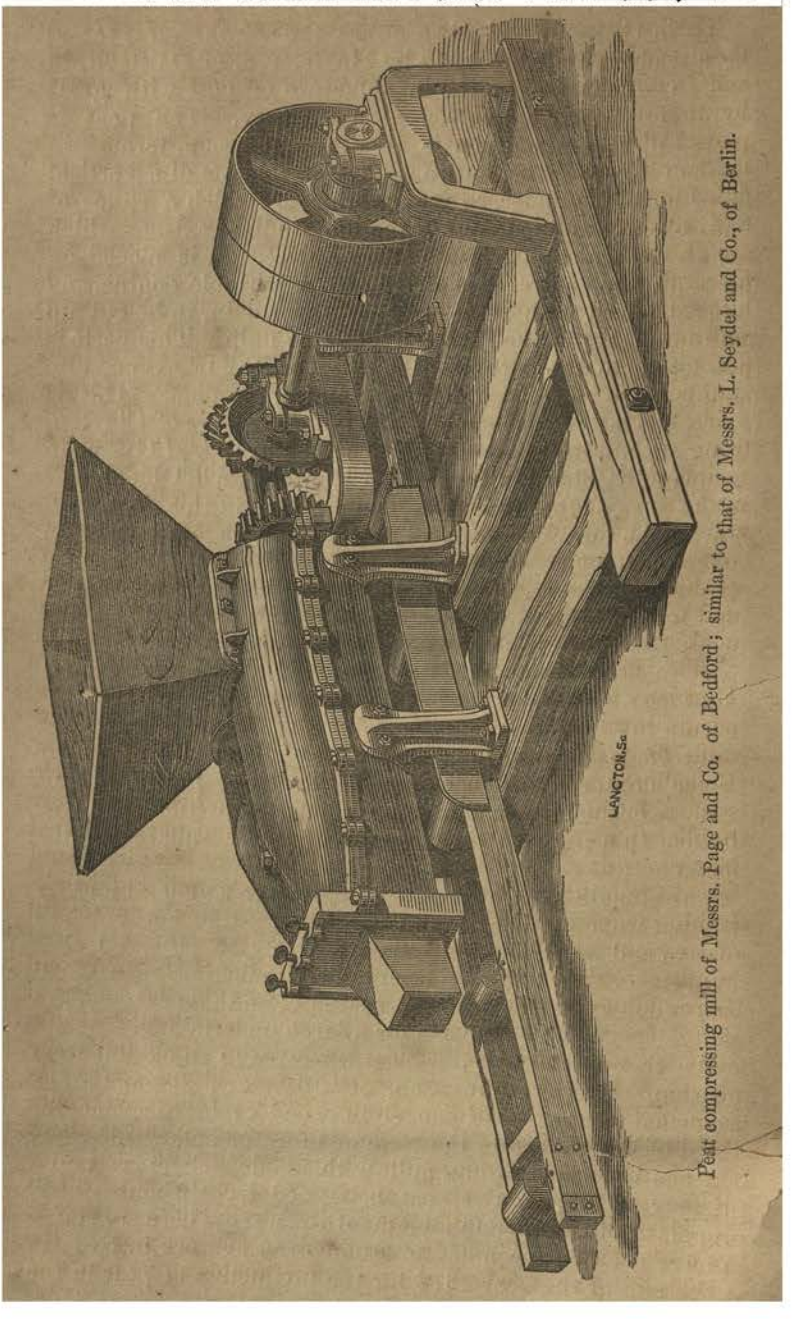
Sweden is very rich in peat; merely in the southern and midland parts of the kingdom, there are about 12,000 square kilometres of bog, of depths ranging from two to ten metres. Except in the most northern districts, still rich in wood, very large quantities of peat, in the general absence of coal, and the great wealth of pure iron ore, are annually worked in Sweden. Though no statistics have been published on the subject, it is well ascertained that by far the largest portion is either simply cut in blocks, or worked by treading, or at most macerated in Hasselgren's simple *Krahn*-mills, the product of each process being afterwards simply air-dried. The method

known in Germany and Sweden as the *Kranmühl* process was already invented in 1845 by Hasselgren, of Dalsland, in Sweden, who carried on the manufacture of peat with great energy for nearly a quarter of a century. The peat is worked up into a stiff paste in a tun or coop, termed in Swedish *Kran.* The entire apparatus consists of a vertical tun or hollow cylinder, to the interior of which a series of sharp blades are fixed, and in the longitudinal axis of which turns a shaft, also fitted with sharp knives. It is placed on the heath, the central axis driven by a portable engine, and the peat mixed with some water is thrown in, to be cut up and thoroughly worked into an equable pulp. This paste is then let out at the bottom of the cylinder, to flow at once into moulds, or to be treaded on the Hanoverian plan. This is clearly the leading principle of the later processes of Clayton, of Versmann, in London, of Weber in Bavaria, of Gysser in Baden; of Eichhorn in Bavaria; of Ruschmann in Oldenburg; and of many other inventors and workers in this field. In fact, all the machines sent to the Exhibition embodied the leading idea of Hasselgren.

A simple mode of masticating peat is that consisting in merely subjecting it to the action of spirals enclosed in a pipe or casing which, while mixing it up, propel it out of one or more mouthpieces. Seydel of Berlin had two presses thus, one with a single, another with two screws, but without the macerating knives below the hopper. The machine of our countrymen Messrs. Page and Co., of Bedford, was similar to the double-screw machine of Seydel of Berlin, but of better workmanship and of more solid construction. It was fitted with a pair of twin screws, and had a square mouthpiece.

The outside view at page 290 will give a general idea of its appearance. The screws are intended to act both as cutters and propellers. It need scarcely be observed that these machines, however useful for production on a small scale, such as for households situated close to a peat bed, are not claimed to be applicable for a large undertaking.

Another machine of this class consisted in an exhibit from Sweden. S. H. Samuelsson, of Föskefors, Rada, sent a somewhat rough small model in wood of his machine for compressing peat into the form of tubes or hollow tiles. It consists of a macerating mill with wooden stampers and a plunger which, on the peat being fed in, without water, propels it out of a drain pipe mouth-piece. There are stated to have been 88 machines of Samuelsson at work in Sweden at the end of the year 1872 for the production of peat in the form of tubes

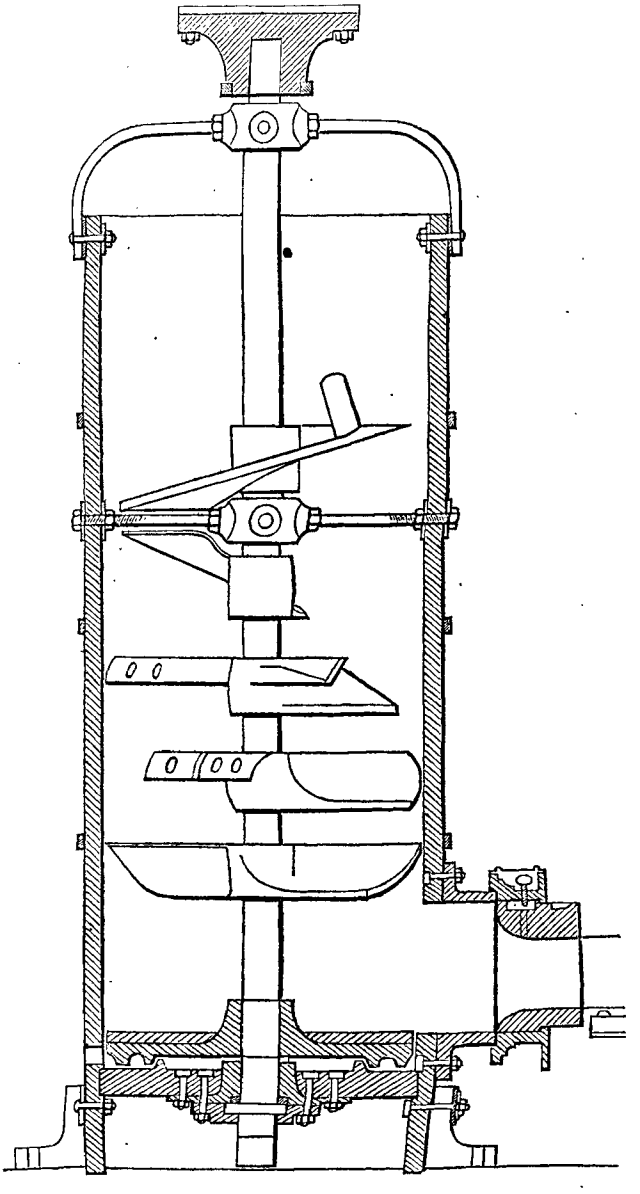


Peat compressing mill of Messrs. Page and Co. of Bedford; similar to that of Messrs. L. Seydel and Co., of Berlin.

The inventor informs us that there are now in all 170 of these small cheap machines at work in Sweden, Finland, and Denmark; and that the combustion is much facilitated by the tubular shape, especially in domestic stoves, more particularly if his special grate be applied. They can be driven off a horse gear by one horse. The peat first of all falls into a horizontal casing, fitted with knives on its sides, and within which revolves a horizontal shaft to which knives are also fixed. The horizontal casing is prolonged beyond the macerating portion, and is there fitted with an open channel, into which the peat makes its way. A stamp, worked up and down by gear on the machine, compresses the mixed up peat into this channel. On the return upwards of the stamper, the mass of peat is pushed forwards by a plunger made to reciprocate along the open channel and fitted in front with one or more cylindrical pins. As the plunger reciprocates, it drives the peat out of a mouthpiece in front, at the same time stamping out in its substance one or more holes. The peat tiles thus formed are then taken on trams and a temporary line to the drying places. This machine is evidently one of that class intended to work on a small scale, and to afford the wealthier classes, in the absence of wood or coal, a cleaner fuel for domestic use than hand cut sods.

The most noted maker of peat-condensing machinery in Germany is perhaps Herr Schlickeysen of Berlin. His name occurs several times in these pages as having delivered pug mills for peat, and we have seen that the authorities at the Benedicthütte abandoned their Schlickeysen peat mill. He sent a large brick pug mill to Vienna, and indeed Herr Schlickeysen applies his mill to drain tiles and to patent fuel manufacturing, as also generally to mixing, kneading, and working up other plastic bodies. As a pug-mill and brick-making machine it is probably the most deservedly successful of any extant, on account of its simplicity; and very large numbers indeed are now in use in all parts of Germany and surrounding countries. As can be seen in the annexed sketch (page 292), the machine consists of a vertical cast-iron cylinder, with a central vertical shaft driven from below by gearing. On the shaft are keyed strong blades, shaped as segments of an archimedian screw. Each of these covers one-third of the surface of the circle, and are set as knives about the shaft in a continuous spiral, but in such wise that each segment is placed one above another at a distance of about one-sixth of the whole diameter of the circle, while cutting as far underneath. No blades are fixed to the interior of the cylinder. Above, where the peat enters into a hopper, is a scraper, for preventing adhesion to the sides while giving

Cross section of Schlickeysen's Peat Pug-mill.



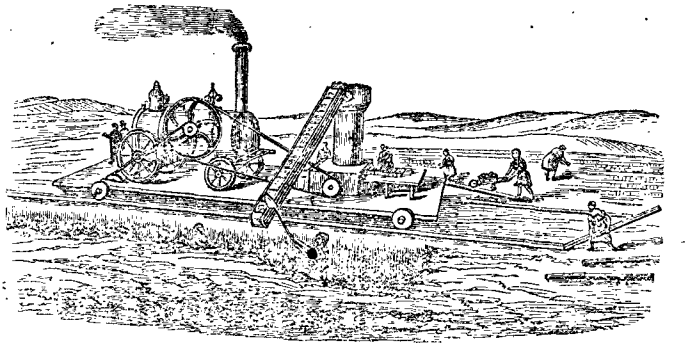
a downward propulsion to the peat. As the peat is forc
downwards, getting disintegrated on its way, it is propell
out laterally through three mouth-pieces at the bottom of t

cylinders, and as it issues is cut off by hand into pieces about 10 inches long. These are set on boards about three feet by one wide, and carried on barrows to the spreading and drying ground, the boards themselves being brought back. The larger sizes made by Herr Schlickeysen have not been found so successful, and he now makes but three. The Dublin Commission on Peat examined one machine of small size and one of the largest. The small machine they inspected "was employed in the neighbourhood of the town of Brandenburgh, in Prussia, in making dense turf for burning bricks in a Hoffmann kiln. The peat found here was that of a marsh or moor, and not of good quality. The production of this small machine was found to be about 10,000 pieces of dense peat for 12 working hours, and the number of persons employed, including the engine man, was seven. The above quantity of dense turf, in average air-dried condition, is equal to about 4½ tons. The portable engine was of 4-horse power. The large machine was in operation at Herzfelde, in Prussia. It was supplied with a double delivery through two mouth-pieces, at opposite sides of the machine, and its capability was found to be a production of about 35,000 pieces for 12 working hours. The quantity in air-dried condition may be taken as weighing 15 tons, and the number of persons employed, including the engine-man, was 22, of whom six were women. The engine was a portable one of about 8-horse power. In both instances the number includes all hands employed, from raising the raw peat to spreading the pieces on the drying ground. At Herzfelde this work was done by contract, for rather less than 2*s.* for each 1,000 pieces, exclusive of the working expense of the engine and the wages of the engine-man, both of which are defrayed by the proprietors. Here also the dense turf was made for burning bricks in a Hoffman kiln, and was produced by the proprietors for their own exclusive use.

According to these data the total cost of labour in the production may be estimated at about six shillings and sixpence per ton. The accompanying sketch (p. 294) shows a Schlickeysen mill set on an iron carriage 28 feet long, receiving also a portable engine, in order to be able to set the whole on a pair of rails to the cutting in the bog. The peat cutters at once throw the peat on to an elevator, which raises it into the hopper above.

Perhaps the most important exhibition of peat was that of the Princes of Schwarzenberg; and the process by which it is made deserves the most earnest consideration. Outside their pavilion was a notable trophy sent from their peat works at Julienhain, on their estate of Wit-

Schlickeysen's Pug-mill and Engine adjustable to cutting in bog.



tengau, near Gratzen, in Bohemia; the substance was both rough and worked, and also in the form of charcoal. The Wittengau peat-bog is about 15 feet thick and its proportion of ash ranges with the depth from two to five per cent. The great value acquired by the wood in the neighbourhood through the construction of the main line of the Franz-Josef Railway forced Prince John Schwarzenberg to find a substitute for wood as fuel. He ordered several journeys of inspection to Germany and Switzerland in order to be able to settle on the best plan extant for working peat. The process adopted on a large scale at Julienhain consists in a combination of the Swedish method of maceration with the Hanoverian method of treading the macerated stuff into a sort of long cake to be afterwards cut up into smaller pieces. The macerating machine and its portable steam engine are placed in the field, and so adjusted forwards with the progress of the work. Ten men are employed besides the engine driver. The engine also works an elevator and a pump. The elevator consists of an endless india-rubber band crossed with slips of wood, and it reaches to the bottom of the peat bank. All the strata of the drained bog are cut away together, in the shape of terraced steps so that the men may not be too far from the elevator. The greatest difficulty of all is caused by the roots and bits of trees; and one set of workmen have to prepare the peat by picking them out. The peat brought up by the elevator falls together with a stream of water into the hopper of the macerating apparatus. Macerators of different constructions are employed, the most preferred consisting of a pair of horizontal rollers, with short blades fitted all over them, and erected towards the upper part of the machine. At the lower part there are horizontal spirals which receive and propel the masticated peat, through tubes from six to eight feet long, towards

the mouth-piece of the machine, out of which it issues in a continuous stream. It falls on a table, whence it is scraped off into hand trucks, taken away on a wooden railway, and thrown down in heaps. It is then spread out with the shovel and trod by the feet into a long flat cake. Some days later it is again stamped down, and is then marked into squares. After a time, dependent on the weather, these bricks when sufficiently dry are separated and set up in annular heaps. When quite dry they are stacked away in common sheds. The air-dried bricks are eight inches long, three wide, and one inch and a half thick. Many experiments have been made at Julienhain to replace the human feet by kneading rollers or road rollers; but they have not succeeded, one great difficulty being the adhesion of the peat to their surfaces. As already observed, a difficulty hard to overcome is the presence of too many stems and roots of trees in the bog. The picking out of these pieces takes up much time and labour; they cause much loss of peat either from the beginning or from the moulded bricks crumbling to pieces. The peat bricks produced at Prince Schwarzenberg's works acquire very nearly the density of water, and are in all respects said to be equal to the best lignite. The peat plant at Wittengau has now been at work for three seasons, the first being the spring of 1870. It is stated that their number is to be raised to twelve in all; and this fact speaks for the general success of the enterprise. These machine peat works are now probably the most extensive in the world; as they turn out about nine thousand tons per annum.

The Dublin Commission were informed that the total cost of production was about 3 florins and 40 neukreuzers, Austrian coinage, for each 1,000 pieces in the finished air-dried condition, as finally stacked upon the bog, or about 6*s.* 9*d.* sterling per ton. The rate of wages paid to a good workman varied at Gratzen from about 2*s.* to 2*s.* 6*d.* sterling per day.

It will be observed that, at Julienhain, the macerating machine carries out the important function of establishing an average quality down the whole vertical section of the peat bed, ranging from the poor fibrous quality at top, to the dense black stuff at bottom; and that the material is *only cut, and not entirely raised by labour*, as a sort of Jacob's ladder is used to raise it up to the hopper of the machine. It is worthy of notice that machinery experiments of all kinds, involving a very great outlay to the Princes Schwarzenberg, have been conducted at Julienhain; but with the result of the present simple process.

Not dissimilar to the Schwarzenberg process, but conducted at less cost in capital for plant, is that employed by Herr Georg Mahlstedt, of Oldenburg, who sent a machine for mixing and macerating peat. His company for cutting canals and manufacturing peat is stated to employ about 220 men, and six portable engines. This portable peat machine, driven by a portable steam engine, is set on the ground, and can be advanced forward as required. At the back part of the machine is a hopper, fitted with a horizontal rotating shaft, to which are fixed about a dozen sharp curved knives. The peat thereby partly prepared, is received into two casings, each fitted with an archimedian screw which, while still further working up the peat, squeezes it out to the front. The whole is set on flanged tramway wheels, and the main shaft connected to a small force pump used with too dry peat, to pump up water to aid the masticating action. The machine, with its portable engine, has to travel sideways from thirty to fifty feet per day according to the width and depth of the cutting. The peat flows out in a state of pulp, and is conveyed on wheelbarrows to distances sideways from the machine of from 200 feet to 300 feet width, and spread on the land, forming a cake from six to eight inches high. After the lapse of from one to two hours, a workman with boards 8 inches by 12 inches tied to his feet, stamps the pulp down. According to the weather it can then be cut into 12 inch square pieces. These are then left on the ground until they have shrunk about one inch all round, when the square sods are cut into three pieces, by which time the thickness has diminished from 6 in. to 4 in. They are then set up, and can be very soon heaped together.

The cutting in of the moor is also in terraces, in order that its sloping sides may not fall in, and the peat as it is dug out is shovelled on to a portable Jacob's ladder, by which it is at once conveyed into the hopper of the machine. Machines are also set on each side of the cutting.

Each machine costing only about 250 thalers, and no racks or costly sheds being used, the first capital is comparatively slight—a most important consideration in a manufacture lasting such a short period of the year. In 1873 Herr Mahlstedt excavated a width of 60 feet to a depth of 8 feet to 10 feet, to be afterwards pugged in machines on his plan. With 10 men he can work about 3,500 cubic feet of wet peat daily.

Herr Georg Mahlstedt, though he has done so much for the mechanical manipulation of peat, being, we believe, regarded in Germany as one of the foremost workers in that

line, yet considers that working it by hand is much the cheapest method for utilizing peat, especially if the produce is to be used in the immediate neighbourhood of the deposit.

A gentleman of considerable experience in working peat in Ireland, Mr. M'Grath, now of Bradford, the results of whose long experience in distilling peat we quote further on, has obligingly furnished us with a description of his system for winning peat for use as fuel. In the first place a bog is chosen, say, one English mile, or 1,760 yards in length, with a frontage 120 yards wide for drying ground. It is well drained and levelled just as is done with a common brick field. This will give an area of about 43 acres, and Mr. M'Grath finds that an acre of ground will be covered with a layer of macerated peat moulded into bricks of $10 \times 5 \times 5$ inches, allowing for proper air spaces and working paths. When thus covered it will produce only 60 tons of marketable fuel. After three days exposure to the sun and air the moulded bricks may be turned on edge. They thus remain for six days, after which they are built into tiers of seven or eight bricks high and two thick. After three days more in this position they may be either built into ricks on the bog, or removed to sheds erected for the purpose, where they remain for a month, after which time the fuel is fit for the market. In Great Britain and Ireland we cannot calculate on more than six months as the working period for the manufacture of peat fuel in the open air, or, deducting rainy days, we get, say, 120 working days in the season. As one crop of fuel may be removed off the drying ground in twelve days, we get ten crops in the season, or, as from each acre sixty tons may be gathered, we get 25,800 tons off the 43 acres. It is thus seen that the quantity of fuel produced will entirely depend on the extent of bog frontage and area of drying ground. The plan proposed by Mr. M'Grath is to make a portable tramway, parallel to the peat bank, and as near as possible thereto, on which portable macerating machines work. These are fed with the raw material cut by hand labour only. At right angles to this tramway are others at convenient distances from each other, and extending to the extremity of the drying ground. On these tramways ply waggons which receive the macerated peat as it drops from the machines, and by which it is carried to the moulders on the bog. The moulding is done by means of a mould, say, 10 feet 5 inches long, 1 foot 9 inches wide, and 5 inches deep, divided into 12 divisions. This mould is placed on the drying ground and the macerated peat is struck into it directly from the waggons. When the 12 divisions are thoroughly filled and levelled on top by a roller; a boy

comes with a die made for the purpose and divides each division into four bricks, thereby obtaining 48 bricks of 10 × 5 × 5 inches. After this operation is completed the mould is lifted up and removed, being placed in position by their side, and so on.

In the British Agricultural Hall, Messrs. Henry Clayton, Son, and Howlett, of London, had only a photograph of their new peat machine, but with samples of raw peat from Somersetshire, Cambridgeshire, Yorkshire, and Ireland, with condensed peat from Mr. Cooper of Maidenhead, and elsewhere. The firm was awarded a medal of merit by the jury. They state that their peat machinery is now in use by the South Scotland Peat Company, at Dumfries; the Ulster Peat Company, Ballymena, near Belfast; the London Lead Company, Middleton, Durham; the Fenns Bank Brick Company, Llynclys; Yorkshire Peat Company, Hull; by Mr. Richard Key, Dunlewey, Letterkenny, Co. Donegal; by Baron von Carstenn Lichterfelde, Testorff, Holstein; by the Highland Peat Fuel Company, Edinburgh; by Mr. E. Holme, of Copenhagen; and by Mr. G. Arnold, of Tunbridge Wells—these sets of machines, besides others, having been delivered during the course of the last year. As with most modern processes of treating peat, its leading feature consists in macerating. The peat is supplied into the usual hopper within which revolves a shaft fitted with screw blades. On the peat falling down this hopper, it is received into a long horizontal cylinder, through the centre of which passes a revolving shaft, armed with propeller blades, the inside of the horizontal cylinder being also fitted with screws. The peat thereby triturated, issues out in a stream at the usual orifices, is cut into blocks by wires as with bricks, and these blocks are removed for drying under covered sheds. One more peculiar feature of Messrs. Clayton's patent consists in the use of so-called squeezing trucks, into which the peat is filled as it first comes from the bog. These waggons, stated to be only recommended for very wet peat, have holes in the bottoms and sides for the escape of water; water is forced out by a piston acted upon by a screw or lever. This machinery has been often described and illustrated in England in most of the technical and other periodicals; and Mr. J. McC. Meadows, M.E., Dublin, compares its duty with that of hand labour in Ireland, observing that—"under the most favourable conditions its capability is stated to be equal to the maceration or tearing up and mixing of only 75 tons of wet peat per working day of 10 hours. The result is at best not more than 15 tons of dry dense fuel. In actual practice, however, the results would be

" more likely to be under than over 15 tons, perhaps not " more than 10 or 12 tons. The same quantity of black " turf would be produced from the lower stratum of any of " our Irish bogs, by three or four good turf cutters in one " day, at a total outlay for labour of cutting of ten or twelve " shillings."

Compression in various ways, even by hydraulic and steam presses, has been a favourite idea with many peat inventors; but it is to be much doubted whether these attempts were sound in principle; and not one seems flourishing under the test of practice. A compression lasting but a short time has no effect on such a comparatively elastic substance, while a continued pressure on wet peat has as little effect as on a cube of incompressible water. Even the simplest way perhaps possible for compressing has not answered ultimately. On the peat heath adjacent to some ironworks near Neustadt in Hanover, a compendious method of working the fibrous and mossy peat of the district was at work in 1860, for some time. It was cut in the usual way, dried in the sun, and then merely passed through a pair of cast iron rolls, flowing out like the hot slab of iron in a rolling mill, and reduced about two-thirds in bulk. The finished peat had a slovenly look, but it was comparatively dense and tough. The ironworks themselves, however, turned out a great loss and failure. One more successful method is known in Germany as the Lithuanian or Russian plan. It consists in ploughing and turning up the surface of the field several times, in order to dry the material in the air. The peat thus well broken up is collected and conveyed under a falling ram or monkey, the head of which, on its falling, drives the peat into iron moulds. This primitive plan answers for soft fat peat with its lesser elasticity, producing dense stony blocks; but it is evidently unsuited for working on a large scale.

Merkel and Company, of Kolbermoor, Upper Bavaria, showed in the German Department some raw peat and moulded peat (*Modeltorf*), both stated to cost 1 florin 24 kreuzers Bavarian money, or 2*s.* 4*d.*, per centner; and some pressed peat, with a price of 24 kreuzers per cubic metre. They also had specimens of peat disintegrated by the plough and after grinding (*Torfmuell*) such as is used in their peculiar process. A medal of progress was granted to the firm by the jury. Their process, known in Germany under the name of Exter, first carried out at Haspelmoor, and soon afterwards at Kolbermoor, created at first a great sensation in Germany; and it was subsequently tried at Freiburg, in Switzerland, at Neustadt, in Hanover, and at

Miskolcz in Upper Hungary. This method is a modification of that experimented upon by Messrs. Gwynne and Co., of London, and at the Derrylea Works in Ireland. All these establishments, except those at Haspelmoor and Kolbermoor, have been given up long ago. The works at Haspelmoor, situated on the railway between Munich and Augsburg, belong to the Bavarian government; and it is probable that, if their continuance did not depend on a practically exhaustless purse, they would have been long ago given up. Laid down about 15 years ago, we believe, a record of successive changes and plans adopted at Haspelmoor, would form a pretty complete history of the working of peat. The processes employed by Merkel and Co., at Kolbermoor, and by the Bavarian government, at Haspelmoor, may be briefly described as tearing-up the peat, then drying and pressing it at a temperature of about 140° F.

The peat bog is in the first place well drained, cleared of brushwood and properly levelled. From this level surface, a period of fine weather being chosen, a thin layer is harrowed up or ploughed, either by steam as at Kolbermoor, or by ordinary horse draught as at Haspelmoor. The plot to be ploughed is traversed through the middle by a railway. A portable engine sets in motion an endless wire-rope on horizontal pulleys, set up at either border of the land. Four gang ploughs are attached to the rope, and as the latter is set in motion, they break up the strip of peat they pass over. The locomotive and the pulleys are then moved back, and the process is repeated. The surface yielding this thin layer of peat loses some of its moisture, by evaporation in the air, and the loose layer itself when made up into small heaps in the condition of fine *Torfmuel*, soon also loses still more. After being thus partially dried, this loose peat is removed to capacious storing sheds, where it becomes the stock of raw material for future manufacture. In adjoining buildings the peat mould is more fully dried and warmed by artificial heat, and in the manufacture it falls into horizontal tubes, in which it is compressed by rams or plungers worked by eccentrics, driven by steam power. The cost of the compressed turf was ascertained by the Dublin Commissions in the latter part of the year 1872, to be about twelve shillings per ton. But this amount does not include the large original outlays upon buildings and machinery and other items.

The Dublin Commission observe that they "were informed "that the State direction in connexion with these works, had "under consideration, the question of discontinuing the system "altogether," and that "this system is essentially the same as

" that for the working out of which works were, subsequently " to the year 1860, erected at Derrylea, in Ireland, where the " results were commercially unsuccessful." We have been informed in Germany that the tiles thus produced, when beginning to kindle, are apt to split up into fragments, and to issue from the chimney in a dangerous stream of fiery sparks; and that the actual cost of production, all items taken in account, of the compressed peat at Haspelmoor is really not less than about twenty shillings per ton.

IV.—The Drying of Peat.

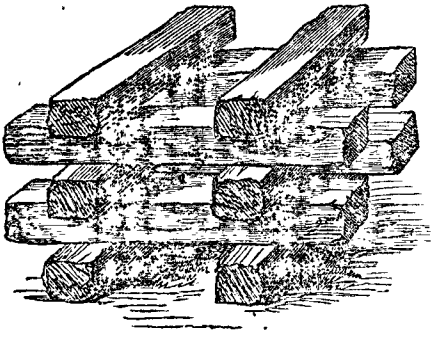
The great difficulty with peat, perhaps the greatest difficulty in our climate, consists in drying it. Peat from the bog contains from 75 to 90 per cent. of water; so that to get a ton of perfectly dry peat from four to sometimes as much as even ten tons have to be raised, containing from three to nine tons of liquid injurious to combustion; and at least the major portion of this mass of water must be driven off in some way, leaving the peat with at the most 25 per cent. of free water. Even when peat has been well dried, it yields, according to Dr. Vogel, when heated to boiling point, as much as 16 per cent. of water. Its hygroscopic nature is such that in moist weather it takes up water to at least 20 per cent. of its weight. It has happened in Germany, that close sheds filled with partially air-dried peat, have been burst by the swelling through absorption of moisture of the peat in damp weather.

In the building given to the so-called " additional exhibits," was a model of a peat-drying shed by Theodor Pohl, of Joachimsthal, in the Bohemian Erzgebirge. This drying shed was made with a light roof raised on wooden pillars, the peat being laid cross-wise in three tiers, the bottom tier resting on a couple of strips of wood. In the pavilion of Carniola was shown some raw peat from the Ribsera Forest, 3,523 vertical feet above the sea level. It was begun to be worked in 1869, principally for the puddling furnaces of the Rothwein Iron Works. A model of a wooden drying shed, similar to those used for common bricks, an iron spade and a knife for cutting the pieces into bricks, were also exhibited. These implements are somewhat similar to those used by the Salzburger Torfmoor Company.

We have described above the method and tools adopted by that company at the Benedicthütte for cutting peat by hand labour. Whenever the sods cut are of sufficient consistency from off a well drained portion of the bog, they are at once piled in the mode indicated in the accompanying sketch.

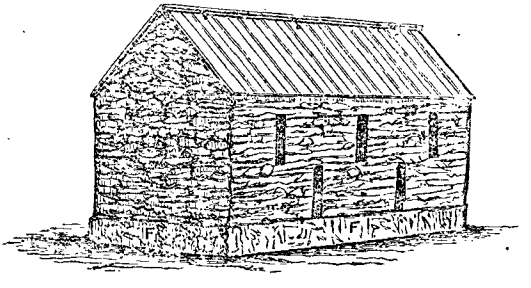
(Fig. 1). If not sufficiently dry to prevent their breaking or bending some additional time is allowed to elapse. The

Fig. 1. Pile of Peat bricks.



local term for this form of pile is *Kastel* or "small box," and the number in each pile is from six to ten. The upper four to eight pieces get dry in a short time, and they are then stacked in so-called *Tristen*. Herr Kalus considers that "to bring the dry peat into magazines is quite impracticable "for manufacturing purposes, as the stacking in heaps or "*Tristen* is in any case unavoidable in order to afford time "for the complete drying while protecting the peat from the "worst weather. As, however, all labour given to peat is so "dear on account of its large volume and the great number "of the bricks, it is best to do away with this removal and "to turn the *Tristen* itself into a storehouse, only removing "the peat when it is actually needed." The *Tristen* are therefore, simply stacks in the form of a parallelopipedon, as shown in the accompanying sketch (Fig. 2), left with slits or

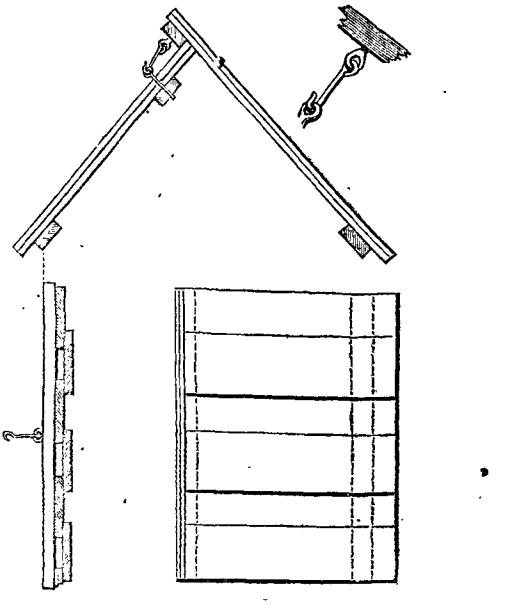
Fig. 2. Peat stack or "Triste."



openings which much further the subsequent drying, one and a half meters apart, and set upon a foundation F, F, F, consisting of waste sods and bits of peat. These stacks are

generally two meters wide, from three to four meters high, of any length, and are so set up as to form a sloping roof which is covered with planking. This covering is made of light boards in suchwise that a pair of sets hinge together and can be at once taken off one *Triste* and adapted to another. As shown in the sketch (Fig. 3), they hang together by means

Fig. 3. Plank covering of Peat stack.



of a hook and lugs, the boards being lightly nailed together, alternately one above the other, as indicated. This mode of stacking also entirely replaces storehouses which, for large quantities, require a heavy capital and are subject to considerable outlays for repairs. Even in the depth of winter with a heavy fall of snow on the ground, the peat can be fetched in light trucks running on a wooden railway and taken direct to the furnaces.

Herr von Rosthorn has communicated to us a rough and ready plan, shown in the annexed cut (Fig. 4), applied in some Austrian districts, but evidently only applicable to fibrous peat. It consists in setting up tall vertical poles, armed with tiers of transverse spars, and set up in the bog at short distances from each other, like a field of hop poles. On the transverse horizontal arms the spade-cut sods are strung. This plan is cheap and very effective in fine weather, as he rays of the sun and currents of warm dry air have

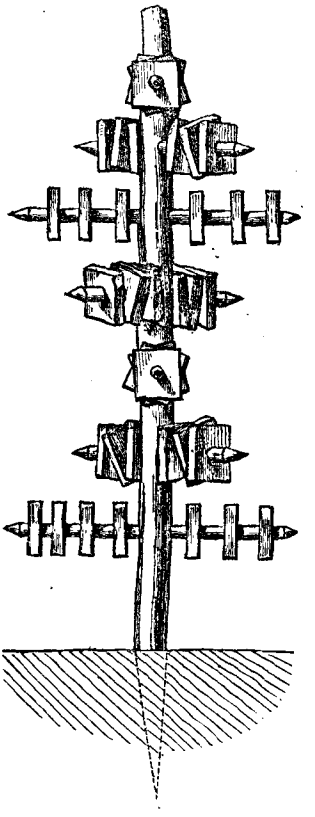


Fig. 4. Peat sods being dried on poles.

everywhere unimpeded access. When dry the bricks are stored away in large sheds erected on the bog.

At many peat works the bricks are dried on racks erected in a line on the bog, and roofed over, but otherwise open on all sides. This method is very expensive in first cost on account of the large areas requiring to be covered for even a comparatively small production; and in renewal, as the timber rots away on the bog by the end of ten or twelve years. If simple drying racks and sheds are expensive, this is still more the case with the drying chambers and *hot houses*, constructed with blowing and exhausting fans—costly plans which have ruined many undertakings, and have engulphed fortunes. The simplest method of drying consists in setting up the peat bricks in pyramidal piles, at intervals from each other, and when dry storing them away in heaps covered with straw or rushes. This plan is of course cheap, but it

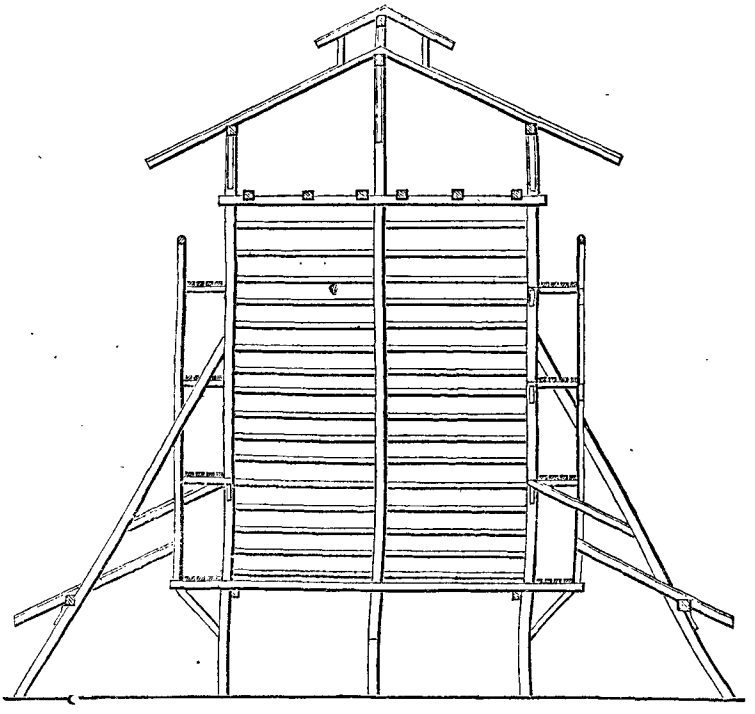
takes a long time, and is entirely dependent upon the continuance of fine weather.

The absurdity of attempting to evaporate the 75 or 90 per cent. of water contained in fresh hand-cut or freshly macerated peat, can easily be seen by reckoning out the thermal units required to evaporate such an amount of water by means of peat itself. The following experiments made by Mr. M'Grath, formerly of Athy, Kildare, bear on the question and are interesting in themselves.

The experiments were conducted under an 8-horse one-flued boiler. The pressure was constantly kept at 30 lbs. on the square inch during the combustion of the fuel. All the steam generated passed through a refrigerator, and, being condensed, was collected and weighed. In the first experiment, 850 lbs. of water were evaporated in three hours by 200 lbs. of the best brown prepared peat of Athy bog, or $4\frac{1}{4}$ lbs. water evaporated by 1 lb. of peat. In the second experiment 420 lbs. of water were evaporated in one hour and 24 minutes by 100 lbs. of the same peat, or $4\frac{1}{5}$ lbs. of water were evaporated by 1 lb. of peat. In experiment No. 3, 800 lbs. of water were evaporated in three hours by the combustion of 100 lbs. of good bituminous coal, or 8 lbs. of water to 1 lb. of coal. On a fourth trial, 520 lbs. of water were evaporated in two hours and 45 minutes by 200 lbs. of the best black or bottom peat, or $2\frac{3}{5}$ lbs. of water by 1 lb. of peat. This inferior result, unusual with black peat, was possibly due to its having deteriorated by exposure, as it had been kept 18 months.

It is in drying that another difficulty of the mechanical processes has to be encountered. All condensed, or moulded, or stamped, or even macerated, peat, is dried with greater difficulty and keeps in the moisture longer than common cut raw peat. This has been found by experience, in spite of the strange theories about maceration opening the fibres, and similar fancies; though, undoubtedly, of all plans of mechanical treatment mastication most facilitates the getting rid of the water. Peat must also be dried as gradually as possible, or is very friable. For obvious reasons, as with wood, the slower peat is dried, the less it is liable to cracks; and this drying must take place more equably and gradually under cover from the direct rays of the sun and hot blasts of air.

We describe elsewhere Eichhorn's process for balling peat, and its results, as complete as we have been able to make them, appear in a tabulated form. The annexed sketch shows Eichhorn's drying chamber, as modified by Lieutenant Von Horn, of Stockholm.



Von Horn's Eichhorn drying chamber.

It consists of an open frame work of wood provided with inclined drying floors arranged one above another, leaving a space between them. These drying floors are composed of a number of laths so arranged as to form a kind of lattice work, through the openings of which air can pass and circulate amongst the balls of peat placed thereon. In the upper part are tramways, upon which the cars containing the balls to be dried travel. The balls are turned into the spaces between the drying floors, down which they roll until the floors become filled. As the blocks become dried, they are let down from the lower ends of the inclined floors into a store room situate beneath, fresh blocks to be dried being supplied at the top as fast as the dried ones are removed. The chamber is also roofed over to protect the blocks being dried as well as those in the store room from rain or from too much sun.

V.—The Carbonisation or Charring of Peat.

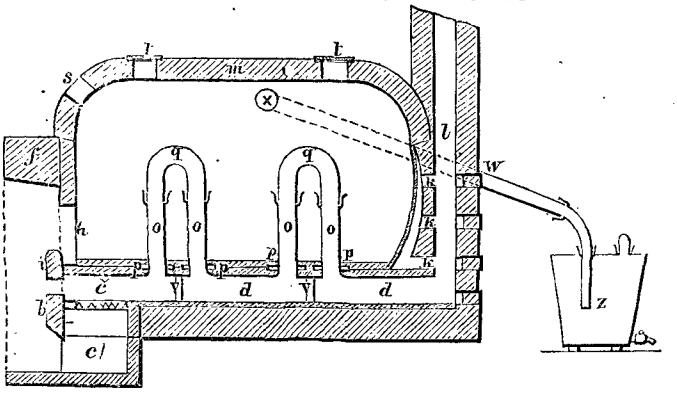
Lottmann's Peat-charring Kiln.—In the part of the main building termed the *Kohlenhof* were to be seen some very

fine specimens of peat and peat charcoal, forming a tall pyramidal trophy, sent by Herr Lottmann, of Chlumetz, in Bohemia. At that place numerous experiments were made about 1840 to produce charred peat, in heaps as with wood, in tall furnaces with moveable tops, in a covered furnace, a central tube, in retorts and other plans. These attempts were not completely successful from different causes, such as small yield, inequality in the product, undue consumption of fuel, and difficulties in quenching the peat charcoal produced. In 1860, Herr Lottmann succeeded with his peat-charring kiln, shown in the engravings at pages 40, 41. It consists of a brick oven with a vaulted top, provided at its base with a central canal for the fire gases from one central grate in front, and with an inner casing heated from two other grates. This conduit is broken by a pair of cast-iron U-pipes, rising up into the mass of peat in the oven, and up and down which the fire-gases pass on their way to the chimney. On its brick foundation *a* are formed the firing conduit *d*, and the ash pits for the pair of fire grates *b*, *b*. The firing conduit *d* is divided at *v*, *v*, by thin brick partitions, and is covered at *p*, *p*, *p*, *p*, with a cast-iron socket, in order to receive the pipes *o*, *o*, *o*, *o*, formed with knee joints at *g*, *g*. Through this canal and the connected pipes the fire-gases are conveyed from the fire *c* to the chimney through the middle of the kiln and the peat it contains. The plate *r* is used for clearing out the ashes in case any should be left behind. From the foundation the body of the kiln is carried up in an elliptical shape. An inner covering is built up of unburnt fire-bricks in such wise that it forms a united whole, resting on outer casing by means of burnt fire-bricks set at short distances *n*, *n*, *n*, apart. The two casings unite above, and run together into the vault, in which there is an opening for supplying the peat to the front, and two openings *t*, *t*, for feeding in peat while the kiln is being worked. Between the inner and outer casing are the two other fire-places *i*, *i*, the fire-gases from which, surrounding the inner casing, proceed to the chimney, being regulated by three dampers. In order to retain some of the products of distillation, there are two bent pipes on each side of the arch; they both open into a vessel, within which tar water and peat tar are deposited. In front a cast-iron framing *h* is built in, with a cover for carrying in the peat and withdrawing the charcoal; the window-like spaces *a*, *a*, in the brickwork are opened after the charge is done, in order to cool down the inner casing; but must be bricked up during the firing.

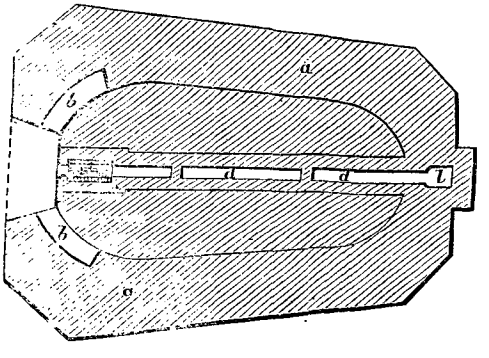
The peat must be charged in as close as possible. After some hours the moisture issues from the pipes *w*, *w*, into the

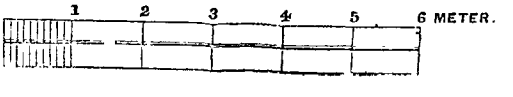
LOTTMANN'S PEAT-CHARRING KILN.

LONGITUDINAL CROSS-SECTION



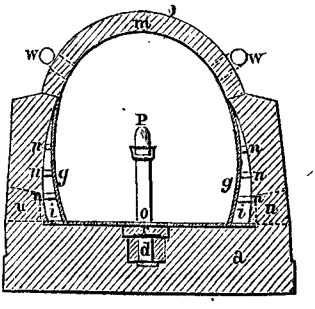
PLAN OF FOUNDATION.



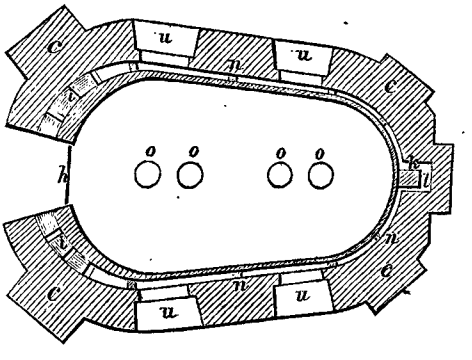


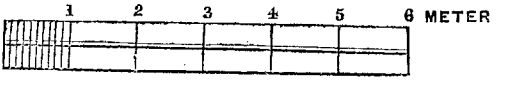
LOTTMANN'S PEAT-CHARRING KILN.

CROSS-SECTION.



PLAN.





vessel; later on, as the temperature rises, the tarry vapours make their exit. Twice or three times during the charge, additional supplies of raw peat have to be filled in through the openings *t*, *t*. At this stage, quite dry peat, lessened in weight by about 20 per cent. is contained in the kiln. The charge lasts from 50 to 60 hours, according to the proportion of moisture in the peat being charred and contained in the waste peat burnt on the three grates. Each kiln is charged on a Tuesday, is ready on Thursday, and is left to cool till Monday, when the charge is drawn. Each kiln contains about 20 cubic meters of raw peat, five have to be filled in after the first charging. About one-half of its contents, the amount of waste pieces of peat are used in firing, and from eight to nine cubic metres of charcoal are drawn. The cost of winning and charring the peat, besides the maintenance of the kilns inclusive of management, amount at Josefsthal to 2 florins 85 kreuzers Austrian currency per cubic metre of peat charcoal. Fifteen of these kilns have been regularly at work since 1860 at Josefsthal. Herr Lottmann intends to further improve his kilns, by applying inclined or stair grates (*Treppenröste*) for heating them, in order to be enabled to use up the smallest waste pieces of peat; and, secondly, to conduct back into the fireplaces some of the escaping gases during the carbonisation stage, so as to further save fuel.

Herr Kalus has informed us that the coking or charring of peat is conducted at Benedicthütte by mixing it with a portion of wood, and burning it in heaps as with charcoal. The resulting peat-charcoal is found to be better than wood charcoal for smith's fires and in the manufacture of glass.

With the special end in view of obtaining charcoal, the French processes of MM. Bocquet and Bénard are being carried out in their main features in Austria. The pressing question of the day there is not so much to utilize peat in dwelling houses,—for wood is still abundant enough to be used in the economical porcelain stoves of the country, —nor for the locomotive, as most lines have more or less easy access to lignite and other coal,—nor for puddling and working iron as that is done by different forms of gas reverberatory furnaces using peat,—but rather to entirely replace wood charcoal in blast furnaces for smelting iron. Mainly with this purpose in view there has been formed a large company now working in Carinthia, under the title of the Franco-Austrian Peat Company, of which Herr Joseph Edler von Rosthorn is the engineer and working partner. This gentleman, of British descent, is known in England as the inventor of "*Sterrometal*;" of the remarkably ingenious and unique system of rifling field guns adopted since 1863

by the Austrian army; and he is now directing his inventive powers to peat. The Company began by employing the French Bocquet system but, applied to a much more fibrous peat than that dealt with by the inventor, it afforded a very indifferent product. They are now trying experiments with machinery planned by M. de Rosthorn. The peat is excavated down to eighteen feet under water, and the material brought up is dropped into canal barges which convey them to a mill, there to be ground up into a paste. The ground up peat is supplied into another set of barges, which convey it to a moulding machine. The excavating apparatus, a modification of the French hand *louchet*, and intended to bring up only one prism of peat at a time, consists of a square iron box, open at top and bottom, the four bottom edges being made to cut. This cutting tool is held all round by a series of flat bars, of a length in accordance with the depth to which it is wished to excavate. The top of the hollow cutting tool is fitted with a pair of hinged lids which, as the cutter descends into the peat, are necessarily lifted up and thrown back. As the cutter is drawn up, the return resistance closes the lids, and a prism of peat is thus fished up as it is caught on the top of the adjustable lids or valves on the cutters. It is then thrown into the adjacent barge. The frame and its cutter are worked up and down by one man turning a pinion on a rack held on standards fixed to a truck running on wooden rails. The raw peat floated to the mill is lifted up from the barges by means of Jacob's-ladders into a hopper at the top of the mill. This hopper is fitted with spiral revolving knives, which cut it into strips and propel them on to the table of a mill with edge-runners. From this mill the peat, now of the consistency of paste, flows by its own gravity down an inclined shoot into a barge which conveys it to the moulding machines. These machines have the appearance of small hand trucks, into which the pulp is supplied. The bottom of the truck is formed of a double series of moulds fitted to an endless pitch chain, running on a pair of toothed rollers. One of the rollers being caused to revolve, the moulds advance, taking up the paste, which is prevented from falling out of the bottom of the truck by the close contact of the moulds with its sides—until, when the moulds are bottom upwards, the bricks of peat drop out on the sward below. This machine is also worked by one man. A somewhat similar apparatus was designed some years ago by Professor Schafhäutl, of Munich. The bricks drop down with their flat sides on the ground, and after three days of fine weather, are turned round on one of their smaller edges by women and children. Being thus left for three days longer, they are piled up in sets of six bricks at a time.

After the same period, they are made into piles of thirty, and are at last stacked in large heaps, to be covered up with straw or rushes. The bricks moulded in this way are, by the time they are air-dried, only 12½ per cent. of the original weight. We have seen some admirable specimens of fuel produced by this machinery, which, as it is only in course of development, it would be uncalled for to give any opinion upon.

VI.—The Products of the Distillation of Peat.

This class was very meagrely represented at Vienna, but, as in other similar cases, this very absence was significant and instructive.

Dr. Breitenlohner exhibited in the pavilion of the Princes Schwartzenberg, a case holding a number of small glass stoppered jars containing paraffine, naphthaline, benzine, photogene, pyrogene, asphalte, *Erdwachs*, naphtha, alcohol, red aniline, oxalic acid, carbolic acid, and other products of the distillation of peat. They were all prepared from the peat of Wittengau, near where the peat works of Prince Schwarzenberg are in operation. Works for the distillation of paraffine, lamp oils, and creosote were in existence for nearly ten years at Chlumetz near Wittengau, but they had to yield to the competition of American petroleum and to the natural ozokerite of Galicia. At present the peat tar is sent to Prague for distillation in the gas retorts of the city works. It was not found to adapt itself to the production of lubricants, nor to that of lamp-black, as the product was too greasy on account of the presence of paraffine.

O. Degen, of Copenhagen, sent some glass jars, containing peat charcoal and bye products, consisting in tar, liquid ammonia, and sulphate of ammonia. Nothing else of the kind was in the Exhibition. It is now 85 years ago that Lebon distilled paraffine from peat. In 1849, the Irish Peat Company carried out a similar process, and soon afterwards works were laid out in Bohemia, Russia, Friesland, and in France. These undertakings, however, found it impossible to continue after the discoveries of Pennsylvanian, Canadian and Rangoon petroleums; and the utilization of coal shale to obtain paraffine and photogene. While large fortunes have been made by the distillation of shale, great losses have attended any similar working of the richest peat. A number of the distillates from peat were shown at the International Exhibition of 1851, and large fortunes were wasted between thirty and forty years ago, in both England and Ireland in attempting to profitably distil from peat naphtha, paraffine, ammonia, and allied products. These projects were revived in North Britain,

on a large scale, about 13 years ago, but with the same results.

Of all the attempts to distil peat with profit, the most noteworthy was undoubtedly that of the Irish Peat Company at Kildare, above alluded to, on account of the large scale of the operation, the considerable sum, said to be 60,000*l.*, spent on the works, and the great amount of public attention the business excited at the time. The originator was the able chemist, Mr. Rees Reece, who employed a kiln much like a blast furnace with a blast of air for maintaining the combustion of the peat at the lower end of the kiln, in order to produce the heat for distilling the peat at the upper end. The peat distilled gave nearly 2½ per cent. of a tar from which the oils and paraffine were obtained by subsequent distillation and treatment. Though it is not likely that a similar attempt will ever be again made, the following notes due to Mr. D. M'Grath, of Bradford, who superintended the Irish Peat Company's works for 13 years, will be interesting. Apart from the large first expenditure on the works, the inferior character of the peat, practically yielding only two gallons of oil and paraffine per ton, and the high cost of the peat itself, Mr. M'Grath observes that :—

1st. The peat was never as dry as Mr. Rees Reece calculated upon, often containing over 50 per cent. of moisture instead of 20 per cent., proportionately reducing thereby the amount of products and increasing the cost of manufacture;

2nd. All the products obtained were more costly and difficult to refine that was expected;

3rd. The duty having been taken off spirits of wine reduced the value of the naphtha, a very important product, from 8*s.* to 2*s.* per gallon, a price which would not pay the cost of manufacture of sulphate of ammonia, because its economical manufacture depended on the separation of the naphtha from the ammoniacal liquor;

4th. The largest and which was considered the principal product, the heavy oils, could not be sold at any price owing to their bad smell and colour. Of course these objections could be removed by re-distillation and other expensive treatments, which would make them marketable, but the expense,—like the artificial drying of the peat,—would be so great as to stop the manufacture altogether unless other applications for them could be discovered. A fresh application was indeed found out after a year or two, and it consisted in mixing them with a large proportion of foreign oils. The mixture made a good lubricant; but it was still offensive, and it probably could not be sold now in the market at any price;

5th. Young's mineral oil coming into use about the same

time would have produced a failure of the business, even if no other cause had been in action;

6th. Lastly, nothing could be worse than the management. After the first two or three years of the existence of the works, Mr. Reece was often away for several months at a time and the direction placed in the hands of gentlemen sent down from London who really knew nothing whatever about the manufacture, in fact did not know even the rudiments of chemistry, the result always being complete disorder and loss in every branch of the business. The only good and economical feature of the whole affair was the amount of gas (carbonic oxide) produced and made available with the greatest possible ease for heating purposes. All the hydrocarbons were necessarily extracted before the gas entered the furnace. The average amount of the peat distilled each week was 150 tons. It was estimated that the calorific effect of this gas was about 75 per cent. of that which could be evolved by the combustion of the 250 tons of peat in the ordinary way under a common steam-boiler furnace.

An extract from a recent pamphlet by Mr. J. McC. Meadows, M.E., will approximately fix the dates of the beginning and cessation in Ireland of these undertakings. It is further important as proving that peat can, with fairly good management, be worked in Ireland to advantage:—"Nearly "fifty years ago, an extensive track of undrained bog upon "the Shannon, at seven or eight miles distance from Lime- "rick, became the scene of busy labour. From its nearness "to the river, and as it did not lie much above the water, it "may be said at that time to have had more the character "of a marsh, than of a firm bog, but this circumstance did "not discourage enterprise. A substantial pier for boats "was built, and from the Shannon a canal was cut into the "morass, and branches were extended through it for drainage "and transport. These preliminary works were not executed "without meeting with some difficulties, but a day very "soon came when they bore fruit, and from two to three "hundred persons might afterwards be seen there every "season, all employed in the cutting and saving of turf. "This undertaking was originated and carried on by the "proprietors of a distillery in Limerick, and from it all the "fuel they required for their works was obtained and con- "veyed by water to that city. The turf-cutting work was "systematically carried on, and joined with it was the "gradual reclamation of the bog itself. About the year "1842 the distillery works were discontinued by the pro- "prietors, and the bog properly passed into the hands of the "late Mr. James Macnab, who from the first had conducted "its management, and from the year 1842 up to he present

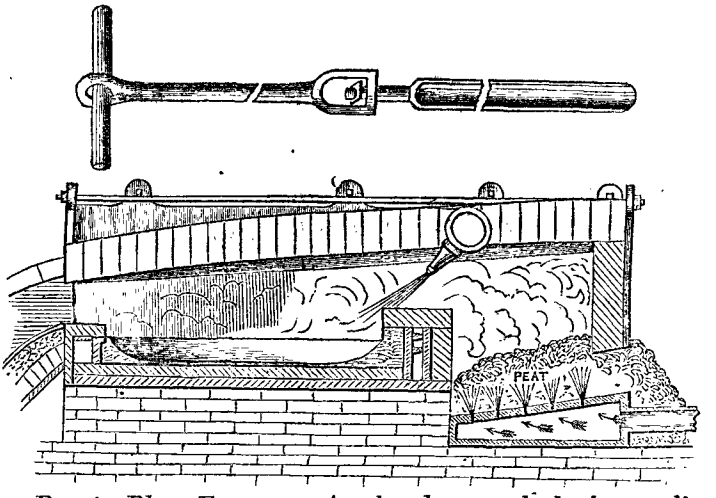
" the raising of turf for sale to the public, coupled with the " reclamation of the bog, has been followed there as a " special business. The cutting commences usually in the " month of March, and is continued until August, and the " quantity made and disposed of in the condition of ordi- " nary cut turf is of late years about five thousand tons " annually. The writer examined these works, and he has " been assured by the said proprietor, Mr. Alexander A. " Macnab, that in no year has unfavourable weather pre- " vented the safe harvesting of the turf; in evidence of " which he referred to the fact, that, notwithstanding the " wetness of the summer and autumn of the year 1872, the " quantity of turf cut by him, about five thousand tons, " was all saved in good condition and disposed of to the " public a month or two before the end of the year. A " tract of about fifty statute acres of the cut-away bog has " been reclaimed into excellent pasturage for cattle, and " now realizes a rent of 85*l.* annually, and a further quantity " of very nearly forty statute acres is in progress of recla- " mation. Around the house and offices there are about " eighty acres under grass and tillage, with fences inter- " spersed with shrubs and edge-row trees; and as an illus- " tration in Ireland of the spirit which elsewhere upon a large " scale converts morasses into money, and in their place in- " stalls the harvest, Mona Lodge, for by that name the once " old waste by the Shannon is now called, may be referred to, " as well with credit to its energetic owner as with advan- " tage to all who can take a lesson from such useful industry. " The turf is here for the most part cut and saved at con- " tract prices with the workmen, and it was sold last season " at rates equal to about *six shillings* and *sixpence per ton.*"

Lighting Gas from Peat.—Peat has also been proposed to be distilled for gas in towns; and it is used in this way in many German factories adjacent to peat beds. Herr Kalus, of the Benedicthütte, informs us that careful experiments with the Salzburger Gesellschaft peat showed that 56 kilogrammes of air-dried peat yielded 400 Viennese cubic feet of lighting gas; the same quantity of artificially-dried peat 470 cubic feet, and respectively 25 and 29 pounds of charcoal. One cubic foot of the gas gave an average lighting capacity of 6,734 candles. Amongst German factories using peat gas is one at Kolbermoor, Upper Bavaria, a spinning factory.

The large number and increased size of retorts, and attendant increase of expense required for gasworks of considerable extent, using such a light material as peat are objections which fall away in smaller establishments intended to supply small towns or manufacturing works. The other

objections to its use in this direction are the moisture evolved, and the greater amounts of carbonic acid.

VII.—The Applications as a Fuel of Peat.



Peat in Blast Furnace.—As already remarked, the application of peat the most important to Austria would be its use in the blast furnace without admixture of other fuel. We have not been able to find that peat is yet used anywhere alone for this purpose. Herr von Rosthorn states that kiln-dried peat, mixed with more or less, generally about one-third, charcoal, has been in use for the last 35 years in the blast furnaces at Ransko, at Pelles, at Tachau, and at Josephstadt, in Bohemia, and at Stieflau in Styria. Other places in Austria where peat is used in producing or working iron are:—Voitsau in Lower Austria, Spital am Pyhrn, Lietzen in Styria, Ebenau, Mauterndorf, Sinuhub and Thalgau, in the Salzburg district, Kessen near Hall in Tyrol, and elsewhere. The furnace at Josephstadt is worked with peat charcoal, some of the others with air-dried peat. Herr Lottmann, whose peat-charcoal kiln we have described, informs us that this blast furnace is only 36 feet high; its construction being also exactly the same as that of blast furnaces fed with wood charcoal; so that the burden of the charge is not much. The proportions of the ores are also the same. Herr Lottmann works usually with one-half wood charcoal and one-half peat charcoal, each fuel being charged in alternately. For many weeks, as much as two-thirds peat coke and only one-third wood charcoal have been used; but the peat must then be of a good firm quality. Peat charcoal from stiff resinous peat is, as regards

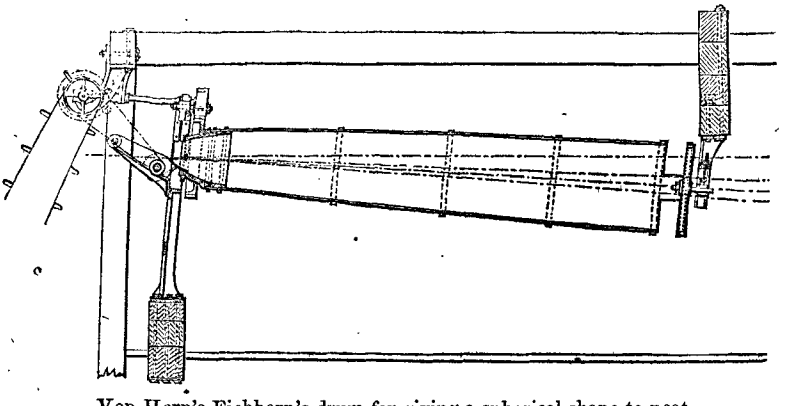
calorific effect and capability of bearing the charge, equal to soft wood charcoal; peat charcoal from light fibrous peat is, with respect to the same qualities, as nine to ten. The coke used at Josefsthal is made from hand-cut air-dried peat, and hence the most varied qualities, dependent on the strata in the bog, are utilized. Herr Lottmann obtains a better charcoal from peat macerated by machine, and it can be used without the admixture of wood charcoal; but, up to the present, he has found it too expensive for the purpose. He has also used small portions of balled peat—*Kugeltorf*—but as he states without any advantage, as it has to undergo the process of carbonization in the blast furnace at the expense of its own material, and of time and space in the furnace. Necessarily, only peat charcoal from peat containing a small per-centage of ash can be employed. It may be noticed that all peats are not, as often supposed, quite free from phosphorus or even from sulphur; so that the advantage of purity for metallurgical applications, on which so much stress is often laid, is not universally true. Some kinds are even known as "vitriol peats."

Mr. Samuelsson, of Föskefors, Sweden, informs us that, in the blast furnace, four measures of peat are found to equal in duty one measure of peat coal.

Kugeltorf, or ball peat, for use in the blast furnace.—The Radmeister *Communität*, an iron smelting company at Vordernberg, in Styria, showed a number of irregular spheres of peat. The managers of the Vordernberg works are of opinion that peat or peat charcoal must have a spherical shape for use in the blast furnace, in order to allow the passage of the blast; and to better resist the burden of the charge in the furnace. Lieutenant von Horn, of Stockholm, also exhibited balls of peat, and some of these irregular spheres, looking like large potatoes, were coked or charked. Both at Vordernberg and in Sweden the same process for making these balls, invented by Herr Eichhorn, of Bavaria is in use. In Sweden there are two works of the kind, one at Vargarda in Vestergoetland, and the other near Vaug in Laen Berebro, possessing in all 18 machines. The process, embodying some modifications in detail by Lieutenant Leopold von Horn, has been patented (specification No. 3330, *A.D. 1872) in this country*, and is being introduced by *Mr. Albert C. Pelly.*

The original establishment, set up in 1868 by Herr Eichhorn himself near Aibling in Bavaria, was carried on by him up to about 1866 with great financial losses. It is, however, now being continued on a small scale by Dr. Herold, a medical man of Munich. Besides Sweden, however, the patent is being also taken up in Russia. There can be little

doubt that the notion of working peat into balls is sound in principle. Lying on a smaller surface, the balls can dry more easily, and the air has access to them from all sides; the resulting contraction is more gradual and concentric; the absence of corners affords better resistance to rain and damp; less space is taken in storage; there is less waste in transport, from there being no corners to knock off; on a grate the balls roll into an even layer and allow access of air between their interstices; and with a good draught they burn with a white flame without smoke or smell or a clinkering ash. For household purposes baked peat is much liked in Bavaria. Apart from considerations of cost there can be no doubt that a sphere is the true shape for fuel on a grate especially for peat. The plan adopted by Eichhorn consists in first partly macerating the peat and feeding it into a conical vessel fitted with a central conical screw. This screw forces the peat out at a mouth-piece circular at the bottom in the shape of a long cylindrical rope about four inches in diameter. This is successively cut into pieces about four inches by a knife connected with the machine. The pieces fall at once into an inclined wooden conical drum, as shown in the annexed sketch, about 13 feet long and 1 foot in diameter at the end where the peat enters, and two feet at the other. The peat cylinders are thus roughly rounded during their passage down the drum, and are delivered out at the larger end into trucks to be taken to the drying room.



Von Horn's Eichhorn's drum for giving a spherical shape to peat.

In Von Horn's drum, the bearings in which it rotates can be set in order to vary its inclination, as indicated by the centre lines; and the blocks to be rounded are fed in by an endless band, as shown. We have given elsewhere a sketch of the drying chamber on this system.

At Vordernberg the peat is first pulped by machinery similar to that of Prince Schwarzenberg at Julienhain in Bohemia. Peat in balls is also made in Sweden by hand. The peat being taken as it flows in the consistency of pulp out of the macerating apparatus, it is rapidly kneaded by children into balls. These are laid on the shelves of adjacent racks where, with favourable weather, they get sufficiently dry in about a week's time to be stored away in small heaps under covered sheds. Some figures published by the Swedish Commission at Vienna testify to favourable comparative results as to specific gravity and diminution of hygroscopic moisture. One of Eichhorn's machines at Aibling can produce in 10 hours 65 zollcentners of dry stuff, or 45,000 balls, 700 to the zollcentner, and taking nearly one fortnight to dry.

Peat in puddling and iron heating furnaces.—The first published application of peat to the finished iron manufacture is stated to have been made between 1830-40 at the Pesendorf works at Rottenmann in Styria, where peat was first burnt under the plate-heating furnaces. Successful experiments were then made with it for the puddling furnaces of F. Mayr, at Donawitz, near Leoben in Styria. About thirty years ago, nearly all the ironworks of Carinthia almost solely used wood and wood charcoal; as the lignite was in most cases too distant for cartage, while the peat was not used at all. There are now two considerable ironworks in that country using peat solely. The most extensive deposit of peat as yet worked in Carinthia is that near Feldkirchen, from which the fuel for those two ironworks is obtained. These moors principally contain fibrous peat, which gradually merges with the depth into soft and resinous kinds. They contain from 2·5 up to 8 per cent. of ash, and yield from 4025 to 4325 units of heat according to the centrigrade scale and metric measure. The bricks, generally cut 10 inches square, and 3 inches thick, are air-dried on racks and stored away in covered sheds close by.

The two iron works in question are those of Buchscheiden, belonging to the Hüttenberger Gesellschaft, and those at Freudenberg, the proprietor of which is Count Egger. In the large pavilion devoted to the mineral industry of Carinthia, was to be seen the most important exhibition of all in respect to peat, shown by the Hüttenberger Eisenwerks Gesellschaft, the manager in chief of which is Herr von Frey, a distinguished Austrian metallurgist. Specimens of raw, of dredged (*Baggertorf*), and of pressed, peat were shown from Radweg, Bleystadt, and Osterbauen, as also peat charcoal and ash. From the first, these works were laid down to consume peat solely. Accordingly, the

furnaces built in 1846 at Buchscheiden were so-called *Pultrostoefen*,—literally, "desk grate furnaces,"—on A. Mueller's patent. Instead of fire bars there is an iron plate perforated with holes, and set to a gentle incline towards the furnace proper. The perforated plate forms the top of a casing, much in the shape of a desk, as shown in the sketch, Fig. 1,

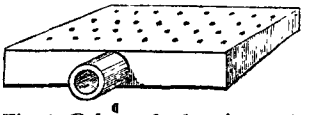


Fig. 1. Pultrost for burning peat.

into which a forced blast of air is conducted. On this the peat is laid, and the blast through the holes is directed into the mass in order to further its distillation into gas, at the same time preventing, by its pressure, the dropping of the dust through the holes into the casing. The complete combustion takes place by means of air, generally heated, blown in through a number of *tuyères* situated just above the fire-bridge.

Figs. 2 and 3 show the combination of this peculiar form of grate with the heating bed; and the direction

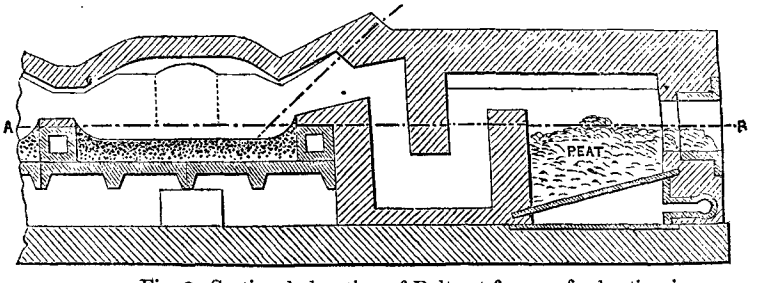


Fig. 2. Sectional elevation of Pultrost furnace for heating iron.

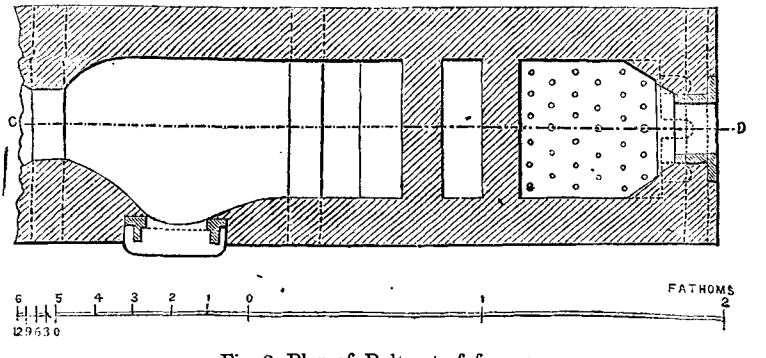


Fig. 3. Plan of Pultrost of furnace.

of the supplementary blast is indicated by a dotted line at an angle to the bed. It will be observed that there are two fire-bridges, with an intermediate hanging arch.

The first idea of this kind of gas producer for peat was due to a countryman of ours, Mr. Dobbs of Pesth, who, about 1840–41, took out a patent in Austria, but did not bring it to bear. Some years later Herr A. Müller, then manager at Buchscheiden, independently hit upon the same idea; and these furnaces have since spread all over Austria for burning lignite, and peat dust in puddling and heating furnaces. Furnaces similar to those on the Pultrost plan have been in use at Luco in Lombardy and at Bellano, on the borders of the Lago di Como, for both puddling and heating furnaces. It is absolutely necessary that the peat intended for furnaces of this character should be well dried; and in this operation there is a loss of at least 15 per cent. At Feistriz in Buchscheiden this is done in special drying chambers or ovens. Up to the year 1870, both puddling and heating furnaces at Buchscheiden were on this construction, when a Siemens regenerating furnace was laid down. The old *Pultrost* heating furnace required, per centner of steel Bessemer rails, 15 cubic feet of dried peat; which, with the loss of 15 per cent. in drying, really amounted to 17 · 25 cubic feet of air-dried peat. The exact economy resulting from the use of the Siemens gas furnace can be best shown by taking the results of three months' work at Buchscheiden, from the 1st of January to the 31st of May 1873. During this period, 17,543 · 69 zollcentners of Bessemer ingots were rolled into finished rails, crop ends and scrap weighing 16,293 zollcentners—a very favourable result as to yield. The expenditure of fuel for the production of these 16,293 centners of rails amounted to 89,968 cubic feet of peat, or 5 · 52 cubic feet per centner. Comparing this with the 17 · 25 cubic feet of peat, burnt in the *Pultrost* furnaces, we get $\frac{5 \cdot 52}{17 \cdot 25} = 0 \cdot 32$; or the regenerative furnaces yield a comparative saving of 68 per cent. If the peat burnt in the drying ovens required for the *Pultrost* be further taken into account, the total saving may be taken at 75 per cent. The expenditure of fuel in this way and the loss of the peat in drying was carefully estimated in 1872.

As already noticed, up to the present day, light fibrous peat is in use at Buchscheiden; which may account for the comparatively high figures of consumption. The following

short table gives a more complete comparative statement of the performances of the two kinds of furnaces:—

	Cubic feet of peat with Pultrost.	Cubic feet of peat with Regenerative Furnaces.
Puddling furnaces - - -	20·55	6·68
Heating furnaces - - -	17·55	5·62
Production of Bessemer slabs from ingots.	15·73	5·03
Rolled iron - - -	18·24	5·83
Bessemer iron, from slabs - -	16·59	5·31

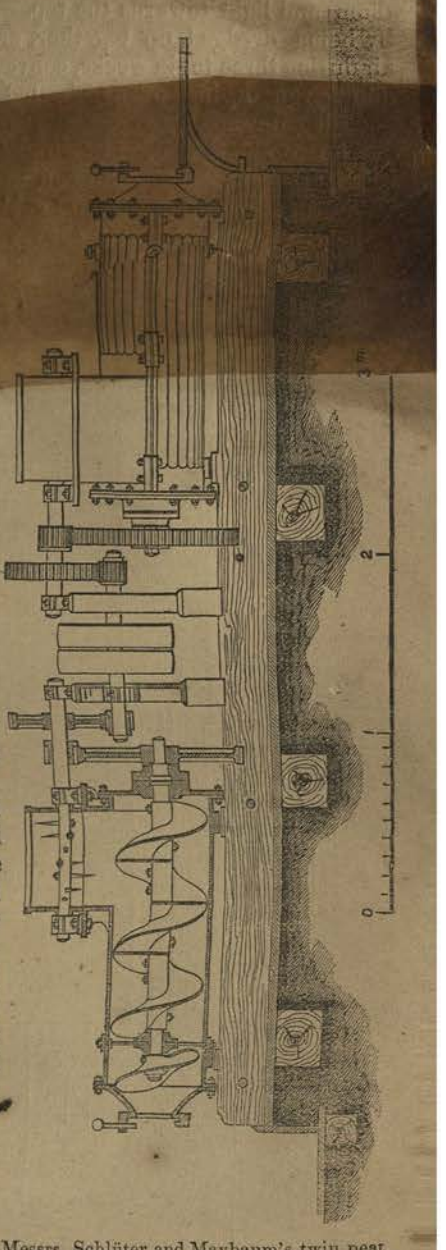
The most important objects, therefore, exhibited from Buchscheiden were a drawing and a model of a heating furnace fired with gas, and with Siemens regenerators. Of this, the most efficient and suitable kind of furnace used for burning peat in manufacturing iron, we give a lithograph The particular Siemens furnace in question was built under Herr Jugovitz's supervision. The construction of the Siemens regenerative furnaces has been as often described, and is so plain from the annotated lithograph that a repetition is needless. Its special advantage as regards peat is that the difficulty of the hygroscopic moisture is overcome by first systematically turning it into gas, and subjecting this gas to cooling in its conducting tubes, as indicated in the lithograph. Of course the fuel itself has necessarily first to turn the water into steam, and this is in so far a proportionate reduction, but the moisture evolved being separated before reaching the focus of combustion, does not interfere therewith. At Buchscheiden, in the gas-producers of the Siemens heating and puddling furnaces are also used up the waste dust from the drying chambers, other waste and tan.

Already at the London Exhibition of 1862, an Italian exhibitor, Signor Gregorini, of Lovero, received a medal for his successful introduction, by means of the Siemens gas furnace, of peat to the manufacture of iron and steel. Mr. Siemens has also used experimentally peat as a fuel in his steel gas furnaces in England; and such furnaces are at work in Russia, at Nijni Novgorod, and at Moscow, in iron and steel works respectively.

With the intention of making charcoal, the Hüttenberger Eisen Gesellschaft set up in 1872 a double or twin peat mill by Schlüter and Maybaum of Berlin, driven by a ten-horse power portable engine. With two men and two boys from fifteen to sixteen thousand bricks 12 inches long by 3½ inches square can be delivered per diem. A drawing

of this machine was exhibited by the Buchscheiden Works. As shown in the sketch, made to metric measure from the drawing, it consists of two horizontal mills, each with an archimedian screw of the usual form, set in a line, and driven off gearing. The peat fed into the hopper is first macerated by the knives fixed on a rapidly rotating horizontal shaft, as it drops on its way to the archimedian screw, which propels it out at the mouthpiece. Black soft amorphous peat, much easier to work than that from the upper portion of the moor, is treated by this machine. This machine has been too little used, having been delivered too late for 1872 to be able to speak definitely about it.

In the same pavilion of Carinthia the second large ironworks we have mentioned appeared, and Ferdinand Count Egger showed here several samples of raw peat as used in his ironworks situated near the Freudenberg Moor. Gently inclined towards the river Gurk, it is well situated for drainage. Its average thickness of 9½ feet is divided as usual into the three strongly marked qualities of heavy soft peat at the bottom, me-



Messrs. Schlüter and Maybaum's twin peat mill, as used at the Buchscheiden Works, Carinthia.

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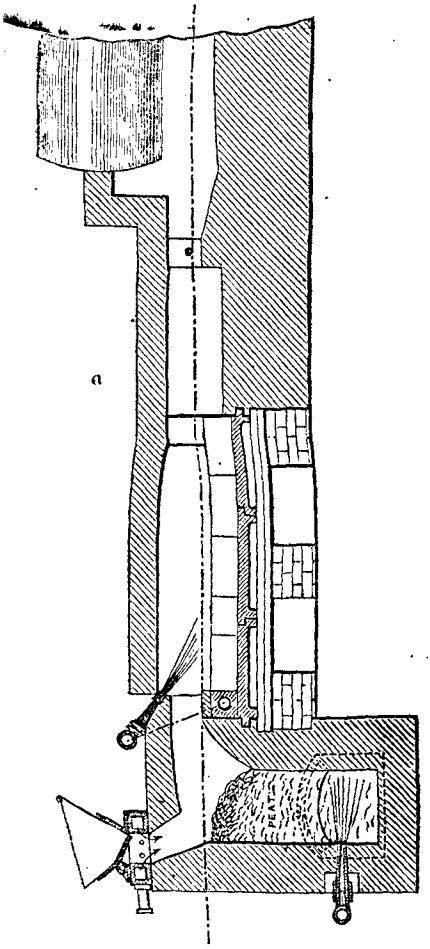
dium and light towards the top. All the three sorts mixed by being dredged up together, are, after being dried in the air during three to six weeks, conveyed in horse-trams directly into seven drying ovens, heated by the waste gases of a puddling furnace.

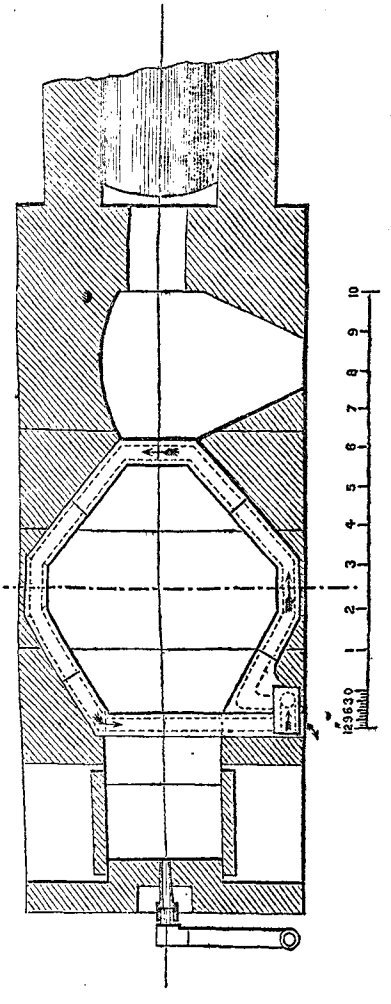
The production of peat bricks is carried on from April till September, and amounts on an average annually to seven millions of bricks or 542,500 cubic feet. Sixty persons are employed in working and conveying the peat, five of whom can produce daily eight thousand bricks. They are dried on 1,200 racks, and within from three to six weeks are conveyed to the works by a railway. The works themselves contain two double puddling furnaces, one single furnace as a relay, one heating furnace for plate piles, the seven drying ovens mentioned above, a five-ton steam hammer, and tilt hammer driven by a water wheel. The puddling furnaces are somewhat similar in construction to the *Pultrost* gas furnace, but with a forced blast above and below the gas generator from a special blast engine.



Sectional elevation of puddling furnace with horizontal boiler at Freudenberg.

The accompanying cuts, giving them in sectional elevation, and in plan (see pages 324 and 325), will render their construction sufficiently clear, while, as with the above sketches of the *Pultrost* furnace, affording information on systematic methods of burning peat in self-contained furnaces. The dried peat is fed in from a hopper set above a casing of fire-brick containing the peat to be burnt.

Below the hopper itself is a perforated casing into which a blast of air is led; and another blast is injected from the front of the furnace into the mass of peat. The peat gas thereby evolved completely consumed, as in the *Pultrost* furnace, by means of jets of air from the *tuyères* above the fire-bridge, supplied with a blast previously heated, thereby cooling the puddling bed, by being driven all round the perforated sides of the cast-iron bed itself. The pressure of the blast is from seven to eight inches of water. These furnaces produce 96 heats or charges weekly, from thirty-five to thirty-seven tons of pig iron. The "loss" with good pig and well dried good peat is from eight to ten per cent. It is impossible to work in these with furnaces with merely air-dried peat, as the temperature necessary for puddling cannot be reached at all. The quantity of fibrous peat required is so large, being from 17 cubic feet to 19 cubic feet per Viennese centner or about 1 cwt. of pig iron, as to be impracticable. A mixture of black, medium, and fibrous peat is therefore employed, which, when well dried, yields the above-named results.



Sectional plan of puddling furnace with horizontal boiler, at Freudenberg.

The annual production is 55,000 centners of merchant iron, with a total consumption of fuel of 9·8 cubic feet of peat per centner. The results with the Müller *Pultrost* at Buchscheiden are especially unfavourable, compared with this, as at the Freudenberg Works, only 9·8 cubic feet of

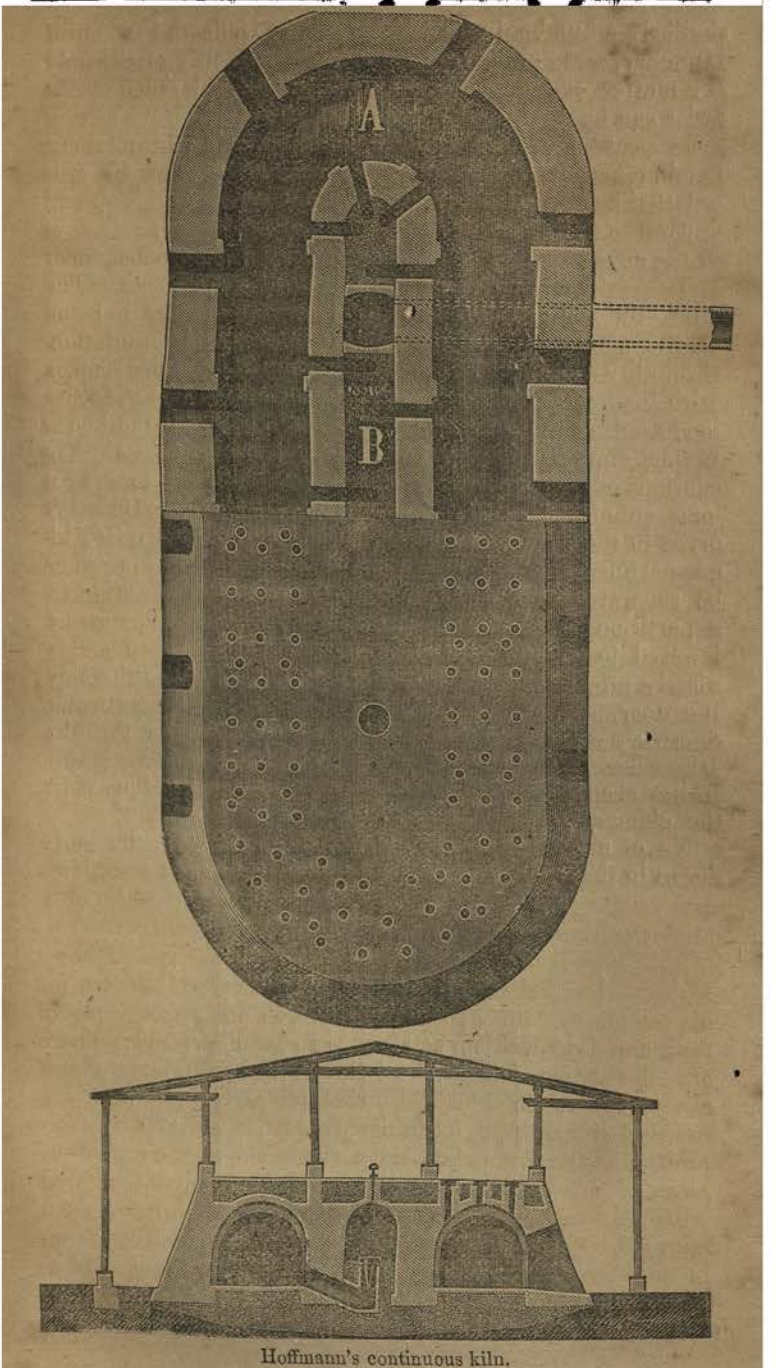
per centner of iron produced are burnt against 22·5 burnt at Buchscheiden in doing the same work. This is mainly because only light fibrous peat (*Fasertorf*) is used at the latter works.

In the Swedish department, Sundström, of Charlottenberg, in Wermland, exhibited the rough peat with which his iron was worked.

Besides having a special manufacture of peat charcoal, as we have noticed, the finished ironworks of Josefsthal, near Chlumetz, work solely with raw peat, and peat gas. The ironworks of Augustfehn, near Oldenburg, produce flat and bar iron, and their nail-rods enjoy a very high reputation. The pig iron, the coal and coke for the heating and cupola furnaces are imported from England; but the twenty puddling furnaces are fired with peat gas, as also the boilers for the rolling mills and steam hammers. The works lie close to considerable peat bogs, connected by a navigable canal and a tram-road. About fifty millions of peat sods are consumed per annum; and peat gas is employed for lighting the works. From 20 to 25 tons per diem of the very best quality of iron are produced at the Augustfehn works. The puddling and heating furnaces are fired by peat-gas generated in special producers; but the construction of the furnaces is kept a secret by the proprietors. Only hand-cut peat is employed, and from 70,000 to 80,000 cubic metres in a dry state, were burnt there last year (1873). We understand that these works during the last four years respectively yielded dividends of 24, 28, 32, and 38 per cent. to their shareholders.

Messrs. Wagenmann, Seybel, and Co., of Vienna, formerly agents of the Messrs. Siemens, exhibited, amongst a set, two drawings, one of a gas producer from peat, another of a producer from a mixture of peat and lignite.

Peat for Burning Brichs, Tiles, Cement, and Pottery Ware.—Herr Friedrich Hoffmann, of Berlin, well known for his celebrated kiln, showed large models and photographs of the same, for which he obtained a medal of process. There are at the very least 280 of these kilns in Germany and elsewhere, which, either the whole, or part of the year, are fired solely with peat. Strange to say, in spite of the expiration of the first patent, not a single one of the numerous kilns of this kind erected in the United Kingdom is fired with peat, so far, at least, as we can make out after careful inquiry. These kilns fired with peat are principally set up in the Prussian provinces of Prussia (proper), Posen, Pomeramia, Brandenburg; also in Mecklenburg, the Elbe Duchies, Hanover, and Oldenburg—all peat countries. There are



Hoffmann's continuous kiln.

similarly a number in East Friesland, in Holland, in Russia, Hungary, and Southern Germany. The quality of the peat is a matter of indifference; and, in fact, fuel the most inferior can be used. As regards bricks, light fibrous peat or moss peat is even preferable to heavy kinds, as it affords a flaming and less intense heat. Some years ago we contributed a description of this, perhaps the most wide-spread apparatus for burning peat, to a technical journal; referring to the accompanying illustrations.

The principal engravings (p. 327) show a longitudinal cross sectional elevation of the kiln, and the same in plan. In the plan the upper portion is in section; with the top, through which the fuel is fed, removed. This top is shown, with its numerous holes down which the fuel is fed, in the lower half of the plan; and the housing, given in the longitudinal cross section, is taken away. The kiln substantially consists of a long railway-tunnel-shaped passage, forming a long annular channel or ring. This ring is divided into 12, or, as in the case of the oblong annular kiln illustrated, 14 compartments, which may be made to communicate or to be separated from each other by the raising or lowering of a partition or damper. These intercepting dampers are lowered in grooves built into the walls of the furnace immediately after each flue; or inserted from the side through the doorways. To each compartment there is an entrance doorway, which can be closed with temporary brickwork. Flues lead from the bed of each compartment to the central smoke chamber, which communicates by a main flue with the chimney outside. The skeleton diagram indicates the action of a kiln constructed with the 14 compartments as shown in the shaded engraving.

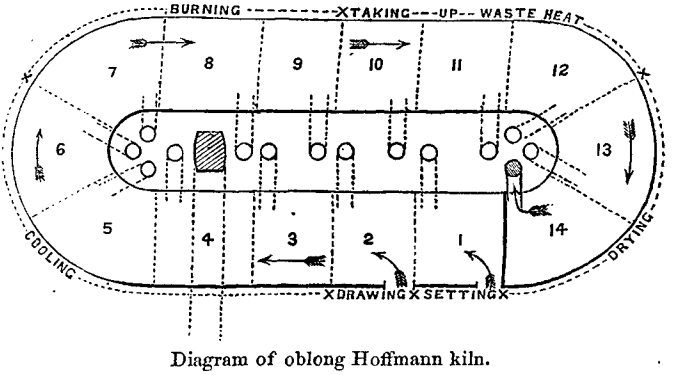


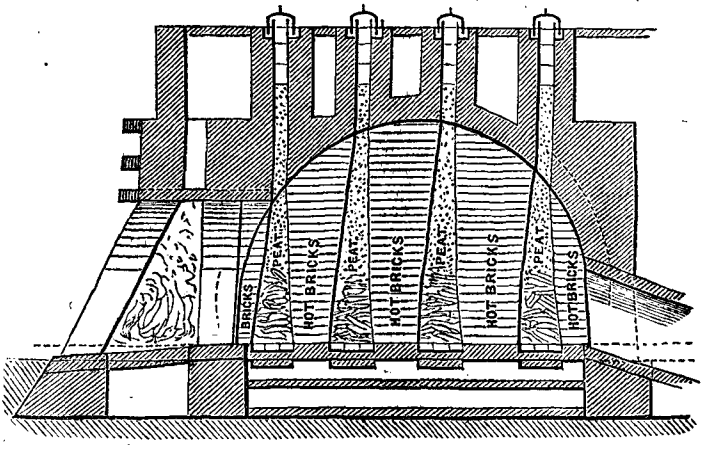
Diagram of oblong Hoffmann kiln.

In compartment No. 1 the green bricks are being set or stacked; from No. 2 they are being drawn, while the air

from the outside, entering here, cools the bricks in the compartments numbered 3, 4, 5, and 6; in the compartments numbered 7, 8, and 9, the bricks are being burnt, and it is into them that the peat is being fed. This is done by simply dropping small pieces of fuel from the holes in the top amongst the already incandescent bricks below, which are stacked up in a simple way rendering this possible. The revolving draught, raised to a high temperature by previously passing through the incandescent bricks, here supplies the necessary oxygen to the fuel thrown in from above amongst them. The fire gases evolved from this fuel then pass into the compartments Nos. 10, 11, and 12, making the bricks therein ready for burning. They at last reach the quite green bricks, out of which they absorb the moisture, driving it directly through the open valve of No. 14 into the smoke chamber, and through the central oblong flue into the chimney. The state and progress of the fire can be at any time easily seen through the apertures on the top, down which the fuel is fed; and as the draught is under perfect control, the heat can be at once raised or lowered. The low temperature at which the gases leave the kiln is indicated by the fact that a high chimney is required for getting up the draught. In the case of the kiln illustrated a chimney 120 feet high is used. There is thus a perpetual current, so to say, of bricks, which is brought slowly to revolve against, and in a contrary direction to, a perpetually revolving draught. In the green stage of the bricks they thus come in contact with air at a comparatively low temperature, and then gradually advance towards higher temperatures until they are at last burnt. Each stack of bricks to be burnt is therefore most ingeniously made to combine successively—(1) the functions of a grate for fuel in a state of subdivision; (2) of a Siemens regenerator for heating both the gas and the air to be burnt; (3) of a drying room for themselves when green; and (4) of a cooling room for themselves when burnt.

Each day one chamber is emptied of its burnt and cooled-down bricks, and another chamber is filled with green goods. The height of each chamber is only from 8 ft. to 9 ft., or about that which a man can reach with his hands, so that the bricks can be easily taken in and out, and they are not subjected to too great a weight when at a high temperature. Any repairs can also be at once done to any one of the chambers as it gets emptied in its turn. In every process of treating clay with a view to drying it in the open air or to burning it, it is absolutely necessary to carry out these operations gradually at the risk of cracking and splitting the

goods. This kiln, from its very gradual action, and absence of sudden changes of temperature, produces no "wasters" from these causes, and the bricks can also be burnt in a much more moist state than in ordinary kilns, as the heat is very gradually brought to bear upon them; though of course it is always best to set them when in as dry a state as possible. By means of the existing air-tight envelope formed by the sand on the top and sides, and by hermetically closing the flue and feed-pipes, the kilns can be closed up and left to themselves for five days and more. They can therefore be easily left alone for twenty-four hours, and thus they need not be fired on the Sunday. In pottery and similar kilns the fuel is encased in open retorts, out of which the gases can flow without the fuel coming into contact with the goods.



Enlarged cross-section of Hoffmann's kiln.

The construction of a kiln using peat does not differ from one burning coal, except that the vertical openings for dropping down the fuel are made somewhat wider. The enlarged cross-section of the kiln will render quite plain how the peat is burnt, on being dropped in the shafts formed while stacking the bricks. The consumption of peat necessarily varies according to the natures both of the peat and of the clay worked up. On an average of many kilns, the cubic volume of the peat consumed is one-third of that of the clay burnt into bricks; or one cubic foot of peat is burnt per three cubic feet of bricks. The two hundred kilns, in round numbers at work, turn out four hundred millions of bricks per annum, consuming from three to four hundred millions of sods of the ordinary sizes made in the peat districts where they are at work.

Peat and other fuels quite worthless and impossible to be burnt on fire-bars, are used with success in this way. For instance:—At the brickworks of Messrs. Weber and Rieder, in Grosskreuz, near Brandenburg, a stratum of peat, about four feet thick, was found upon the bed of clay being worked. On account of its large proportion of ash, it could not be burnt. Since, however, a Hoffmann kiln has been there set up, this peat has been therein used as fuel with profit. It is not improbable that, as in this kiln, the true way of burning peat is in the form of powder, which, as regards drying, would offer great advantages. Good results would possibly attend the burning of peat in such furnaces as those of Mr. J. Bourne, of Mr. Leigh and of Mr. Crampton.

Peat in Glass Furnaces.—The glass manufacturers, Stölzle, of Schrems, and in Suchenthal, and Wokann, in Moosbrunn, gasify the peat in simple generators, and lead the gas into the fire chamber of the glass furnace. The peat is first well dried, or, still better imperfectly carbonized. The Brothers Hardmuth, in Budweis, manufacturers of pottery ware, employ a similar process.

Herr Friedrich Siemens, of Dresden, a brother of Mr. C. W. Siemens, of London, has large glass works at Dresden, in which lignite is burnt in his regenerative gas furnaces; but he has set up a number in other places for using peat only.

Peat as Steam Fuel.—The only special provision we could discover at Vienna for the combustion of peat as steam fuel was exhibited by an English manufacturing firm. Messrs. John Fowler and Co. of Leeds, had a steam traction engine constructed for burning peat on an estate of the Archduke Albrecht in Hungary. The only modification was that the grate surface had 50 per cent. more area than for coal, with the attendant increase in fire-box width and heating surface. In the magnificent special exhibition of the Archduke Albert was to be seen a piece of raw peat, one cubic foot in volume, from his estate in the Wieselburger *Comitat*, Hungary. The area of the bog is 3,000 Austrian *Joche*, and the peat is from three to six feet thick. No other peat came from Hungary, where the forests are still of great extent. The ordinary portable engines of the English makers have a much too small grate and of fire-box heating surfaces for peat, and some loss and disappointment have been caused to German purchasers of engines primarily made for burning coal. It is not impossible that at any rate fibrous surface peat could be burnt in the fire-boxes of portable engines on some of the plans, with slight modifications, now being introduced for straw.

No railway in Austria has adopted peat as a fuel; this is only the case in some parts of Bavaria and Oldenburg. A number of years ago, the administration of the *Staatsbahn* set up considerable peat works, but they were soon given up after the first trials. On the Oldenburg railway and on the line between Meppen to the Rhine, the size and area of the peat stores are astonishingly large. The locomotive fire-boxes on the Oldenburg line are of the common construction, only larger, with firebars somewhat closer, a water jet in the smoke-box to there put out any accumulation of sparks drawn by the blast pipe through the fire tubes, and a chimney of the inverted-cone shape, as in engines burning wood and lignite. The very capacious tenders are covered up and closed in front to prevent the access of sparks from the chimney; and there is an additional covered truck behind for the requisite supply of peat.

Herr Kalus informs us that some experiments on Austrian railways with peat from the Benedicthütte showed that on an average incline of $\frac{1}{155}$ and a gross load of 1,000 Austrian centners, 222 Viennese pounds of peat were used per German mile.

When, as on a railway, there is a question of transport, more than one objection to peat comes to bear. The loss with raw peat in breaking bulk, or unloading, is not inconsiderable, being five and ten per cent. of the weight. Then at least double the weight of fuel has to be conveyed; and, on account of varying quality, and considerable volume, punctuality in the locomotive service cannot so well be relied upon. It is difficult to speak with exactitude about the absolute value as a fuel of peat, as that will depend on the kind of peat — especially its contents in carbon—on its state of aggregation, its mode of preparation, the amount of water it contains, and on the way it is burnt. There is no doubt that a really cheap process of condensing peat would meet many difficulties on railways located far from coal beds.

On a steamer belonging to the Dublin Steam Packet Company plying in 1843 up the river Shannon, it was found that raw peat double the weight of coal ordinarily used did only the same duty in raising steam. This peat was the product of a favourable season for air-drying; when bad or very damp, its evaporative capability was reduced one-third and more. For stationary steam boilers there are localities where it effects much saving. The spinning factory proprietors in Oldenburg use to great advantage under their steam boilers a mixture of half *Bachtorf* and half coal. The clinkering of the fire-bars was found to be thereby prevented.

Mr. Alexander McDonnell, Locomotive Superintendent of the Irish Great Southern and Western Railway, has published some important figures, given by Herr T. Weber, Chief Engineer of the state railways in Bavaria, as to the useful duty of various kinds of peat in the locomotive, in answer to specific inquiries. In answer to the questions, "What are the relative values for locomotive purposes "of pit coal; brown coal or lignite; *stich torf*," or raw peat; "turf manufactured at Haspelmoor and at Kolbermoor; turf "manufactured into small balls near Aibling?" Herr Weber stated:—One Bavarian cubic foot (0·02486 cubic metre) of ordinary and air-dried cut peat, weighing 5,000 grammes, is equal in calorific effect in the locomotive to the *same* weight of peat manufactured by Exter's process at Haspelmoor, to as much as 5,300 grammes of ball peat from Aibling, by Eichhorn's process, and to 2,560 grammes of Wesphalian coal from the Ruhr. As regards the relative prices, without reckoning freights:—

	Pence.
One Cubic metre = 40 cubic feet of ordinary cut peat, costs - - -	26–32
50 kilogrammes = 1 centner of coal from the Ruhr - - - -	13⅔
50 kilogrammes = 1 centner of compressed peat from Haspelmoor - -	7⅓
50 kilogrammes = 1 centner of compressed peat from Kolbermoor - -	7⅓
50 kilogrammes = 1 centner of ball turf from Aibling - - - -	7⅓

With respect to the quantity of ordinary cut air-dried peat "necessary to burn in a locomotive to take a passenger "train a certain distance," compared with the coal, that would be required to do the same duty; it appears that "in the second quarter of 1872, the consumption of *stich* "*torf* for passenger trains was 0·86 cubic metres (or "121·7 kilogrammes coal) a German mile (=4·610755 "English miles), with 13·2 waggons (2 axles)."

These figures are important in several respects. If other evidence were wanting, they prove that no process, whether of mastication, or compression, or even of masticating and subsequently globulating peat, can add to its calorific effect; and it is evident that no process of the kind can increase its contents of carbon or of hydrogen. Any process of condensation, by diminishing bulk, and strengthening the texture, simply gives worked peat more portability than merely cut peat can have. At the same time, we should have expected that the worked peat would have yielded

superior results under the action of the locomotive blast pipe. The popular supposition, however, that condensed peat is nearly as good as coal for raising steam is again proved to be utterly incorrect.

VIII.—The Reclamation of Peat Lands.

In Holland, not less than 40,000,000 tons of peat fuel are raised and dried each year; yielding in excise duty 140,000*l.* per annum.

It is probable that the ways in which the hard working Dutch make use of their peat beds would afford the most fruitful applications, at any rate as regards the reclamation peat of lands. It is perhaps not generally known or remembered that the Dutch, during the reign of William III. and Mary, offered to drain and reclaim into pasture land the whole of the great Irish bog of Allen, in Queen's county, if only allowed to be governed by their own laws. As this bog is lying waste to this day, and as an important example has thus been lost, many will regret that the offer was not accepted. Perhaps it is not even now too late. Some of the richest soils in Ireland are, however, said to be due to a mode of cultivation, very similar to the Dutch plans, introduced by emigrants popularly known in Ireland by the name of "Palatines," and possibly of German or Dutch descent.

The Helena-veen Company exhibited tobacco and flax grown on the two-feet depth of alluvial soil found at Herzogenbusch after removing and working up the three meters thickness of peat. Formed in 1855, this company employs all the year round 300 men and 100 women, besides 250 persons in addition in summer, with two steam tugs for their canal boats of from 20 to 120 tons. The canals of the company have a length of 30,000 meters. They are said to have found their undertaking a source of very great wealth. From documents published on this essentially Dutch branch of industry, we learn that the peat is not entirely removed, but about eighteen inches of it are left on the generally sandy bottom of the bog. Sand is generally thrown out of the canals on the surface; the surface is ploughed over three times, the last time to the depth of about a foot; it is then well manured with a three-inch thickness of compost consisting of fæces, peat ash, and road detritus, and well ploughed and harrowed. The first year rye is sown, then potatoes after fresh manuring, and in the third year rye again with grass and clover, when it is left in green crops for three [illegible] This rotation of crops has been practised in Holland [illegible] than three hundred years. Navigable canals [illegible]tically cut, affording both complete drainage

and cheap communication; the peat, while being itself utilized as fuel, is removed to afford land for culture; and the canals again, leading to the sea, are used, not merely to drain and carry away the peat, but also to convey, as return freights, the requisite phosphatic manures.

During hundreds of years soil was being formed by the successive death and growth of generations of plants, and therefore containing the nitrogen and minerals necessary to plant life. Peat soil is necessarily very rich, and when drained and properly treated becomes of the best quality; Sir Humphrey Davy held that "a soil covered with peat is a soil "covered with manure." Mere peat, however, is just as sterile as sand; neither in the one nor in the other can cultivation be carried on; and a moor is also impregnated with the peculiar peat acid, which only permits the growth of a special flora. This has, after drainage to be neutralized with lime, and the lack of phosphoric acid being once replaced by means of compost, bone dust and similar manure, rich crops can be raised. Tobacco is well known to be the most exhausting of all crops; and this is the main staple of the Helena-veen Company.

The development of the utilization of peat in Holland seems to have been favoured by the heavy import duty on British coal; but peat has been extensively worked there for the last two centuries. In a rough way, peat has been used there from time immemorial. According to Pliny, the inhabitants of the coasts of the North Sea even in his times fished or dredged up peat, leaving it to dry during several days. That country is indeed very rich in peat, and one of their peat bogs, the Peel, is more than thirty miles long and from six to eight miles wide. Widow Sierat and Son, Utrecht, showed a quantity of different kinds of peat from sundry works employing 120 men and 70 women. Kroon, of Leyden, had peat formed by grinding, mixing with water, then stamped down with the feet, cut into bricks, and dried in the open air. J. C. Rahder, of Hoogeneen (Drenthe), peat prepared by his machinery. All the peat and charcoal from Holland had a good appearance. The ashes were said to be used as manure. Herr Rahder's works were visited towards the end of 1872 by the Dublin Commission on peat; and the report states that they were first laid down about seven or eight years ago. The plan is somewhat similar to that adopted by Prince Schwarzenberg. The Dublin Commission state that—

"The macerating mill is a vertical cylinder about six feet high and three feet in diameter in which a vertical iron shaft revolves, driven by gearing of a 10-horse portable engine

Upon this shaft several arms are fixed, which tear up the raw peat, after which the pulp is forced by a screw through a pipe at one side. This pipe terminates in a mouth-piece with three orifices, through which the disintegrated peat finally issues forth, and as it issues is cut off when about 12 or 13 inches long, and the pieces are removed for drying in the open air. The pieces when dry have an average size of nine inches long by 2½ inches square, and each piece in fair marketable condition weighs nearly a pound and a half. In October 1872 this dense turf was being sold at 3 florins and 75 cents per 1,000 pieces, or at a price of about 10*s.* 6*d.* sterling per ton at the works. Mr. Rahder employs five macerating mills and five portable engines of about 10-horse-power each during the turf-making season, which extends from the latter end of April until September. The quantity made by him during the last season was estimated at about 8,000,000 pieces. For working purposes upon this system a temporary railway is laid upon the bog, on which the mill and the portable engine, severally mounted upon wheels travel, and as the raw peat is extracted from the bog the mill and engine are moved onwards, the mechanism being kept close to the place where the peat is in process of being raised. Close by stands a large covered shed, in which the engine and mills are stored, and there is a fitting shop for repairs. The other end of the shed forms an extensive store for dense turf, from which it is delivered into boats on the canal which communicates with the works. At the Hague this dense turf called "Rahderturf" after the maker was, at the time of our inquiries sold, in good dry condition at a retail price of 8½ florins, equivalent to 14*s.* 2*d.* sterling, for 1,000 pieces. The average working capability of each machine was stated to be 20,000 pieces of dense turf for each working day, and the number of persons employed, men, women, and young persons, and including the engine-man amounted to about 22 in all. The best qualities of heavy dense turf, made in the Haarlem district, by kneading and treading are at present sold at the Hague at about 1*s.* sterling for 72 sods, which is also the retail price of the machine-made turf of Mr. Rahder, as well as of the best ordinary air-dried cut turf, the latter being, however, much larger and more light. For purposes of comparison, we may here observe that the retail price of good sound English Newcastle coal was, at the same time, in the Hague, about 1*l.* 16*s.* sterling per ton." Herr Rahder also supplies raw peat, and he employs in all, about 300 persons during the peat season, which extends from the latter part of April until September.

The ordinary way of reclaiming the high peat bogs in Holland has been lately described by Mr. Consul Newnham of Amsterdam. He states that the system of drainage generally adopted in the high moors of the northern provinces of Holland, after a general outlet with sufficient fall has been secured, "is to divide the tract into strips by cutting open "drains of about 39 inches wide by 33 deep through the "whole length. The strips, usually about 136 yards in "breadth are then traversed or subdivided by smaller "drains. Having thus prepared means for drawing off the "water and partially drying the peat nothing further can "be done for a considerable time varying from two to ten "years, except occasionally deepening the drains a few "inches whenever the marshy state of the soil permits it. "As soon as the bog has sufficiently settled down and is "fit to be operated upon, the crust or surface is pared off "with the spade to a depth of from two to four feet so as "to remove the coarse, undecomposed vegetable matter, "which though unfit for fuel is yet carefully put by for "future use in bringing the under soil into a state of culti-"vation. The peat is then cut out in pieces like bricks by "means of a long narrow spade and conveyed to an adjoin-"ing strip of ground which has previously been covered "with a thick layer of the above-mentioned parings where "they are set up in rows to dry. The process of drying "being invariably done in the open air, it depends entirely "upon the state of the weather and it not unfrequently "happens after a wet summer that consumers who have not "laid up a stock of turf dried in the previous year are "obliged to make use of the new stock in a damp state."

With regard to the utilization of peat lands, an important experiment, very successful as yet, is being carried on, besides other places in Germany, on the Königsmoor, near the colony of Augustendorf, about two German miles from Grauenburg. The bog, after being drained, has its surface cut up with a sort of pick with five teeth during the autumn and winter; and this is repeated in the following spring. During warm dry weather the moor is also harrowed with a light hand implement. A bright summer's day on which the wind is high is then chosen; a portion of the moor is set on fire; and this is repeated on every favourable day. The objection is the fearfully smelling smoke, which, in some years, is often carried by the wind from Oldenburg and Hanover so far as to be observed at Vienna and Cracow, and up to the Alps southwards to Lyons and westwards to Britanny. After a successful burning, the field appears covered with half an inch of ash; and buck-wheat is at once sown in and harrowed over.

Each year for six years in succession, the moor is treated in the same way; but the crops diminish rapidly every year after the fourth. This six years cultivation is undertaken by farmers who are said to eagerly compete for it. The land then returns to the State, upon which it is planted with trees, principally birch, but also pine and fir. An unsystematic system of firing the surface of a heath in order to sow buckwheat had long been in use.

Freight being a great difficulty with peat, a system of cheap canals, as in Holland, is necessary for the extension of its use. In the Bremen district as far as Guarrenberg, in the moors near Oldenburg, in the colonies near Aurich in eastern Friesland, in the Ems district near Rauderfehn and Papenburg, favoured by numerous systematically laid out canals, a very considerable trade is done with the peat sent to Hamburgh, Cuxhaven, Bremen, Geestemünde, Bremerhaven, Emden, to the marsh districts and islands of the Baltic. An English Company is stated to have begun operations in the Grand Duchy of Oldenburg, upon Hodges' Canadian process, for cutting a shallow canal and working peat at the same time. The peat produced by Hodges' Canadian Peat Company at Montreal for the Grand Trunk Railway is, by Mr Aikman, and the Railway Company, said to cost 80*s.* per ton, with a production of 3,000 tons per machine per season by 16 horses' power.

In Holland and also in Saxony, near Liebenwerda, and elsewhere, the ponds of water resulting after the extraction of the peat have been applied to pisciculture, and it is stated, with a good profit.

IX.—Sundry Applications of Peat.

Railway carriage briquettes.—W. Lentze, of the Pressed Peat Works of Einbeck, Hanover, showed some beautifully made briquettes of charcoal peat, chemically prepared, such as are extensively used in Germany for warming railway carriages, as also raw, pressed and carbonized peat.

Thatching.—A medical man, Dr. Kœstner of Bordesholm exhibited in the North German department thatching and partitions consisting of raw fibrous peat covered with a varnish.

Pasteboard and paper.—A process for making paper necessarily from fibrous peat, was patented in 1854 in France. Peat is used as a material for paper in the pasteboard factory of Petersburg, in the straw paper works at Elbing, and at the paper works at Emden.

Substitute for straw.—In parts of Bavaria, the dry turf forming the surface layers of some moors has been used for many years instead of straw in cattle stalls, and with

proved economy; the resulting manure being also extremely valuable.*

Manure.—For several years back there has been a factory at work at Landshut for making artificial manure, in which powdered peat is mixed with dung and fæces. Mr. Samuel W. Johnson, Professor of Analytical and Agricultural Chemistry, Yale College, has given considerable attention to the use of peat as a fertilizer of the soil. He states that:—

"When peat, properly prepared by weathering or composting is suitably incorporated with a poor or light soil, it slowly suffers decomposition and wastes away. If it be wet, and air have access in limited quantity, especially if lime be mixed with it, a portion of its nitrogen is gradually converted into ammonia. With full access of air nitric acid is produced. In either case, it appears that a considerable share of the nitrogen escapes in the free state as gas, thereby becoming useless to vegetation until it shall have become converted again into ammonia or nitric acid. It happens in a cultivated soil that the oxygen of the air is in excess at the surface, and less abundant as we go down until we get below organic matters; it happens that one day it is saturated with water more or less, and another day it is dry, so that at one time we have the conditions for the formation of ammonia, and at another those favorable to producing nitric acid. In this way, so far as our present knowledge warrants us to affirm, organic matters, decaying in the soil, continously yield portions of their nitrogen in the forms of ammonia and nitric acid for the nourishment of plants. The farmer who skilfully employs as a fertilizer a peat containing a good proportion of nitrogen, may thus expect to get from it results similar to what would come from the corresponding quantity of nitrogen in guano or stable manure."

Peat Ash.—Potash from peat was stated in the catalogue to have been sent from Russia, but it could not be found, in spite of a persistent search, aided by the officials. It is possible that the ash of some kinds of peat could be utilized. The percentage of ash varies greatly, being from one to as much as thirty-three per cent; the better qualities containing from three to eight per cent. The ash of some kinds of peat in Germany has been stated to contain as much as fifteen and twenty per cent. of phosphoric acid. An ash of this description would be a rich mine for agricultural manure. Of course peat containing more than twenty per cent. of ash is useless in the shape of condensed fuel.

* *Mem.*—In many parts of Ireland, turf is used and even preferred to straw for both stables and cart-houses, and the manure is said by any farmers to be nearly equal to guano.

The Utilization of Peat in the United Kingdom.

We have afforded in the above sufficient evidence that peat can be applied to all the purposes of fuel, to almost all the purposes for which coal and wood are used. It can at least supplement wood charcoal in the blast furnace; it can be used for puddling and welding iron, for glass making, brick burning and similar applications; locomotives can be driven by it, and peat can even be distilled, like bituminous coal, for solid and liquid hydrocarbons. The question only is:—At what cost; or, rather, whether the capital and labour employed in its winning can expect an adequate return. As with the working of coal at great depths, so with the utilization at peat; the question is not one of mechanical possibility but of financial possibility or commercial profit. Now, in the first place, it is a significant fact that though both Belgium and the United States were well represented as regards their natural wealth at Vienna, and while both, America more especially, possess considerable deposits of peat, nothing of the kind was sent by either. These two countries most of all others resemble our own, and especially in possessing rich deposits of coal, easy means of communication, and a high development of manufactures, with the attendant high price of labour, skilled and unskilled. We believe, after careful inquiry, that peat is not worked at all in Belgium. On the other hand, many trials have been made in the United States; but experience therewith is certainly not encouraging. From our consul's reports we see that, in Maryland, for instance, in spite of anthracite coal costing last year 7 dollars 25 cents, delivered free in Baltimore, and after the attempts of two peat companies to there establish themselves, peat is used solely as manure. In Boston, a manufacturer, possessing close to his factory an abundant supply of peat, for the preparation of which he had erected machinery, after using peat for some time, "now "finds it more profitable to procure coal from a distance, for "which he has to pay 4 dol. per ton prime cost, 3 dol. per "ton for carriage," or 7 dollars in all per ton. In Pennsylvania the immense supplies of anthracite obviated any recourse to peat. From Illinois the principal of the College of Nôtre Dame in St. Joseph's County writes: "We have "used from 600 to 800 tons of peat every year since six "years, and our experience of it during the above period "obliges us to give it up for economy's sake, coal being "cheaper. A ton of peat costs 5 dols. 50 c. at the College. "A ton of coal of good quality is equal to $2\frac{1}{2}$ tons of our "peat. In other words our peat contains 30 per cent. of

" combustible matter, while coal of the best quality contains " 80 to 90 per cent."

Near Portland, State of Maine, about 15 years ago a company was formed for its preparation and sale, but it failed with great loss, and since then no further efforts have been made. It was also attempted to mix it with anthracite coal dust.

Mr. Consul-General Archibald writes that " during " and immediately after the civil war, the scarcity of " coal, in consequence of government requirements and " the closing of the Maryland mines, greatly stimulated " attempts to manufacture peat. *Forty-seven* companies, " with capital varying in amount from 50,000 dol. to " 5,000,000 dols. were organised for the purpose of raising " and preparing this fuel. These have all failed and in- " volved in the aggregate an immense loss to their share- " holders. At present, while no statistics exist of the " actual production, it is not probable that, in the United " States 10,000 tons per annum are manufactured of a cha- " racter fit for transportation or market. In some parts of " New England and in Michigan, peat fuel is roughly pre- " pared for immediate use on the spot, and on the Hudson " and in Connecticut, a few small enterprises make a fairly " merchantable article."

Mr. Archibald also describes plans lately on trial at the Berlin bog on the Hartford and Newhaven railroad in Connecticut, which appear to possess considerable merit. The bog covers 75 acres. " The peat is dug and raised one ton at a " time by a steam dredge, and deposited in iron tubs with " perforated bottoms, through which the water drains, whilst " they are being moved to a wooden platform 18 feet high, " 12 feet wide, and 15 feet long. On this platform are two " boom derricks, raising and discharging the tubs on the " platform. The peat falls through openings on the plat- " form, on an archimedean screw, feeding into a mill, where " revolving knives of different dimensions, convert the fibre " and undrained water into a thick paste, which falls into a " hopper. Under the hopper are moulds resting on wooden " tramways, so that when one mould is full another takes " its place. The full moulds are lifted into cars and con- " veyed to a drying ground, where each mould is overturned " and the peat left on the grass. It soon dries, and after " an exposure of forty-eight hours, it is said neither rain " nor frost will injure it. The machinery is capable, if " required, of turning out 100 tons per day for the 150 " working days from April to November. The selling price " of the prepared peat is five dollars per ton," no doubt on the ground itself.

The simple reason of the failures of peat enterprises on a large scale in the United States is that the peat has to compete with pit coal ranging in price last year at the tide-water shipping ports from 5 dollars 5 cents to 7 dollars 15 cents per ton of 2,240 lbs., or with coal at a comparatively low rate. Sooner or later, often without the least aid from science, capital finds out the value it gets for expenditure.

The calorific value of any fuel necessarily depends on its chemical constituents, and no mechanical manipulation can affect these, by whatever fine name this manipulation is designated; whether "maceration" or "mastication" or otherwise. What peat has not got cannot be put into it. To mix therewith coal dust presupposes a local competition with coal, which peat can never sustain; to take oily shale means taking a substance out of which a more valuable material than fuel can be distilled. Now, while an average peat contains only about 60 per cent. of carbon, against generally more than 80 per cent. in average coal, it also contains more than 30 per cent. of oxygen, against only about 5 per cent. in coal. Welsh coal, for instance, generally contains the highest per-centage of carbon and the lowest of oxygen of any British coals. As combustion consists in a chemical combination of carbon and hydrogen with oxygen, and as the oxygen required is already found in the atmospheric air, the more oxygen and the less carbon a fuel contains, the less will be its value as a fuel. Absolutely dry peat has therefore a calorific capacity only about two-thirds that of coal; and as it cannot be absolutely dried except artificially in a kiln, involving expenditure of fuel, peat, even of good quality, with its 25 per cent. of water, can never do more than one-half of the duty of the same weight of coal.

It is worth a remark that, during last winter (1873–4), common air-dried hand-cut peat was being retailed at a number of places in London at actually 3*l.* per ton. As sea-borne coal could be obtained for little more than half that sum per ton, this fancy price for peat was fixed in ignorance of its real value, which, measured by its calorific effect as compared with that of coal delivered into the cellar, should be at most about 15*s.* per ton. The practically new and unknown fuel was evidently estimated by its new acquaintances according to its apparent bulk; and possibly novelty had something to do with it. About 30 years ago, before the many enclosures of commons round London, not inconsiderable quantities of peat used to be sold to the poorer classes.

When we compare the conditions of working this fuel, at the best possessing half the value of coal, we find that peat is under many unavoidable disadvantages.

Coal can be excavated all round the year; as noticed in our tabular statement, the actual number of working days available for peat cutting ranges, in the United Kingdom from 70 or less, to at the longest, 120 days. It is even stated that in the highlands of Scotland and the Hebrides, only the month of May is available for cutting peat. If cut too early it may become frozen, when it crumbles to powder; if cut too late, the chance of any of the warm weather of June and July may be missed for the whole year. Now these months are just those when labour is required for agriculture, and when, therefore, it is dearest. How is the regiment of people required for an extensive enterprise to be employed and paid during the remaining portion of the year? It is clear that a production confined to only a few months or even weeks of the year can flourish only under special circumstances, can obtain only a local importance. In fact, nowhere has peat ever been able to really compete with coal; it is used where no other choice is possible; and at once disappears as soon as coal, even at a high price and low quality, appears on the field. Peat cannot even compete with lignite. Another great difficulty in working peat on a large scale consists in the fact that the expense of carriage increases so rapidly with the extent of the enterprise, as the work necessarily extends over such a large area, an area rapidly increasing with the extent of the undertaking. When the peat has been excavated, dried, and stored, it has to be conveyed to the place where it is to be burnt. While a cubic foot of coal contains about 60 lbs., peat only contains 30, so that with half the calorific capacity it takes up twice the space; or it has twice the weight and four times the bulk of coal able to do the same duty. Under similar conditions, therefore, a colliery more than twice the distance from, say, a given town can compete with the products of a bog, merely as to transport. The loss of peat in transport is also considerable. Even when the difficulty of carriage transport is overcome, the peat necessarily has to be lifted into the furnace; and at the very least, two tons of peat have to be thus raised to get the same duty as one ton of average coal. With, for instance, large waterworks often consuming, say, 30,000 tons or more, annually, and similar establishments, this is a serious item, involving a considerable increase in the staff of firemen. Then, as compared with coal, a storeage room at least fourfold has to be provided for. In practice, the space for storing would have to be probably six times as much.

As we believe that much money is being just now improperly applied in this country, through an insufficient consideration of the conditions of the question, we have tried to facilitate a rapid examination of the subject by means of a tabulated statement.

We have done our best to make this table as complete as possible, but it is extremely difficult to get really accurate figures of the cost of operating with peat. In the first place, patentees and inventors are, for obvious reasons, seldom if ever ready with such figures; in the second, such figures greatly vary, as it is extremely difficult to apply a correct measurement to a material so varying and worked under such varying conditions. In any case, the actual cost price is an extremely delicate subject with peat fuel machinery patentees.

One of the lessons we have striven to inculcate is that the peat question can never be solved by the use of the macerating and other processes, about which so much has been said and published under the stimulus of an abnormal price of coal. The popular notion in Great Britain has been, until lately, that peat cannot be worked to pay; now, however, many companies, under the stimulus of the coal dearth, seem to be running into the other extreme. Such a comparatively worthless material as raw peat can with difficulty be loaded with the first cost, interest thereon, depreciation and repairs of costly and complicated machinery and apparatus. Very considerable undertakings for working peat have been set up at different times in England, America, France, Germany, Austria, and Switzerland; numbers have come to grief, and many of the few in existence have to contend with bad results. The history of all machinery processes is one of complicated beginnings, and of inventions and combinations made to overcome often only supposed difficulties. But it is more than doubtful whether one machine, or even one process, will ever be found applicable to all kinds of peat deposits; as it will probably never be possible to find several large peat works with exactly the same apparatus. Such an amount of uncertainty and variation can scarcely be found in any other branch of engineering.

We doubt whether condensing peat is at all a necessary or even an advantageous way of working a deposit. Its advantages only consist, firstly, in working up the whole vertical section, by which a fuel is obtained generally embodying the average of the different qualities; secondly, in obtaining a product better for transport; thirdly, condensed peat, once dried, takes up and contains probably somewhat less moisture than some kinds of hand-cut peat. That is all. The expense

SYNOPTICAL TABLE OF DIFFERENT MECHANICAL SYSTEMS OF CONDENSING PEAT ACTUALLY BEING WORKED.

N.B.—NINETY-NINE PER CENT. OF THE PEAT USED IS SIMPLY CUT AND PREPARED BY HAND LABOUR.

Owners or Machinery	Where worked	Local selling price of fuel, 1873-74	How long worked	Average number of men employed, and number over or under mid-field	Whether worked "all the year" or "by fits"	How bog worked	How peat obtained, how dug or moss	Number of men, women, and children employed in extraction, in total cost	Proportionate cost of extraction to total cost	How extracted, hand or machinery	Average weight of moss extracted in a peg-mill, or by compression	Whether extracted in a peg-mill, or by compression	Whether subjected to other treatment before being put into the bag	Whether wrought or otherwise prepared, and how	Proportionate expense of preparing and packing to total cost	Whether moulded or otherwise shaped, and into bricks, or slab	Price per ton of moss at railway station	Probable number of months' work in the year	Approximate total quantity, M.T. dried in air or press	How prepared peat intended for drying ground
Hudson Canadian Peat Company	Hudson's Bay Company's Lands, Lake Superior, and Canada	27 at least	6 seasons	120 to 140 days	"Low bog"	Not drained	By steam power			By machine hand						Pats deposited in conducting channels and cut into pieces.		4 Machines	10	By machine dust.
Leavell's	Bottle in New Zealand	?	?	140 days	Not stated		By hand labour				Macerated in a peg-mill	Peat pug-mill	Dependent on mode of evaporation adopted	No		Moulded into bricks		?	10	?
Robert's	Petra, New York			140 days	Not stated		By hand labour				Macerated in a peg-mill	Peat pug-mill	Not stated	No		?		?	10	?
Bog's, on principle of Lindsley, de Reaghal	Kilmore, Ireland	11. 10s. to 1l. 15s.	On trial	90 to 100 days or 3 tons.	Intended to work in "low bog"		By French grand U. ark				Disintegrated by rotary pencil mill	Fluid	Whole vertical action	No		To be cut into bricks		1	5	?
Belcher's	Drenthe, Holland	Nominally, and practical 10s 6d per ton in 1872, 12s per ton in 1873.	6 seasons	200 days	"High bog"	Open drains, leading to sea-board ditch.	By hand labour	?	?	?	Macerated in a pug-mill	Adjustable up temporary railway	Whole vertical action	No					5	5 M.T. per acre, or 25 M.T. per 100 feet drain
The Princes of Schwartzenberg, Schwartzenberg Estates	Bohemia, Schwartz	2l.	3 seasons	120 days	High moss	Natural drainage	By hand labour; aided by a part of Jacob's labour.			By steam power	Macerated, and also aided by treading.	Adjustable up temporary railway	Whole vertical action	No					12	75 M.T. per acre	Hand workmen worked each way.
Clayton, Sir J. Hope, Bart.	Great Britain, Ireland, and Canada		Machine invented and brought out in 1870	70 to 120 days	Not stated		By hand labour	?	Thought to be either 1/6 or 1/8 of total cost, including and excluding road and rail labour.	By hand labour		Fluid pug-mill	Dependent mode of evaporation adopted	No			0.115 to 0.125 M.T. per cubic foot, or 72 per ton.	Could by makers	?	
Fleury's, now purchased by Dr. Jacobi, Upper Bavaria, Ireland	Kaltenmoos, Upper Bavaria		14 seasons		High moss	Natural drainage	Dispersed by steam power till cracked or moist.				Compressed	Fixed	Only steamer plant adapted to harvested silt.	No					4 Presses	30	
Fleury's	Hangenmoos, Upper Bavaria		14 seasons		High moss	Ditto	Dispersed by steam till surface of moss is moist.				Compressed	Fixed	Only steamer plant adapted to harvested silt.	No					4 Presses	9	
The Peat Engineering Company, Limited, Sherbrooke's system.	Norwich, Lancashire.	10s	4 seasons	150 to 200 days	2 to 3 tons	Natural drainage	Dredged by machinery.	6 men	4 per cent.		Macerated	Both fixed and adjustable.	Dependent mode of evaporation adopted.	No					6 Machines	9 to 6	?
Soupper's, Paris	Ourcq, Valley (Oise) France.	2l. to 2l. 10s.	3 seasons	120 to 130 days	Low moss	Not drained	By French "locomotive" machine.			By horse or animals.	Macerated, and also passed between edge runners.	Fixed	Whole vertical action.	Yes					1 Machine		
Dr. Boettger's, successor to Soupper's.	Frankfurt, Germany.		7 season, or 100 working days to Alpine districts.	100 days	High moss; 3 tons/annual.		Dr. Boettger's clearing apparatus.			By horse or animals.	Macerated, and also passed between edge runners.	Fixed to excavator.	Whole vertical action.	Yes					One set of 7 arms; extraction, 1 ton, breaking up 25 tons; screening was 100 tons.		
Schlichtegroat's of Berlin.	Mecklenburg plateau of Germany, Prussia, and Central Europe; also in Ireland.		12 seasons	100 to 120 days	Worked all the year round.	Natural drainage.	Generally by hand labour, aided by Jacob's ladder.			By steam power	Macerated in Schlichtegroat's pug-mill.	Both adjustable and fixed.	Usually whole vertical action.	No		Not moulded, but cut into pieces by machinery.			10, at different times, from 80 to 100.		Hand barrows
Schlichtegroat's	Salzburg		3 seasons		High moss		Hand labour			By steam power	Macerated in a pug-mill	Fixed				Dito			1 Machine	10	
Robinett's	Grand Duchy of Oldenburg.		3 seasons	110 days	High moss		By hand labour, aided by a Jacob's ladder.			By steam power	Macerated in a pug-mill; and passed over by steam machinery.	Adjustable up temporary railway.	Whole vertical action.	Yes		Not moulded, but cut into pieces by machinery.			6, each one week.		
Alloway's	Cragwell Moss, Somerset.	2l. 10s. to 3l. 10s.	Since May last, 1874. 3 tons, principally to Queen's visitors.	Five months, 12 to 15 days.	Low moss	By a main drain, and 3 branches.	Dug up with Uncertain spades.	Uncertain		Uncertain	Macerated in pug-mill.	Fixed	Whole vertical action.	No	?	Moulded into "cads," and bricks.	?	?	?	?
Bellard's	Le Sauzay, near Paris		Several seasons	140 to 150 days	Low bog		By steam barrel.		15–20 per cent.		Macerated in a pug-mill.	Fixed	Whole vertical action.	No		Moulded by hand into bricks.	20 per cent.			
Ekstrom's	Kilfjan Bornsholm in Sweden.		12 seasons	150 days	High moss	Natural drainage.	By hand labour				Macerated in a pug-mill.	Fixed	Whole vertical action.	No		Placed into bricks by machinery.			4 at A.Shop		

Notes of Mr. Paget.

Most of the above figures are taken from the Reports of Mr. Paget.

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SYNOPTICAL TABLE OF DIFFERENT MECHANICAL SYSTEMS OF CONSUMING PEAT ACTUALLY BEING WORKED—*cont.*

N.B.—NINETY-NINE PER CENT. OF THE PEAT USED IS SIMPLY CUT AND PREPARED BY HAND LABOUR.

System or Machinery.	How prepared peat dries.	Area covered by machinery and space for shelter of stacks.	Time occupied in drying. Dependent on favourable weather.	Number of men employed in preparing peat, including cutting, drying, and stacking, &c.	Peat dried per day of 10 hours.	Estimated percentage of loss of peat, dried, in the process.	Approximate loss of dry peat per machine.	Proportion of ash to dry peat, as found by analysis. Proportion of moisture in dry peat as found by analysis. Proportion of moisture in peat as taken in total cost.	Proportion of moisture in peat as taken in calculations, and how obtained, whether by analysis or assumption.	Proportion of ash in peat as taken in calculations, and how obtained, whether by analysis or assumption.	Place peat has to be carried to for burning.	Locality (or area of operations) where machinery is at work.	Estimated cost per ton at works, as delivered on rail, or delivered on board ship, or per cubic or superficial measure.	Total number of men, women, and boys, per machine.	Approximate hours in working day.	Specific gravity of peat when prepared.	Application of peat when produced.	If made into charcoal, coke, or other products, where made.	Local selling price of peat or wood charcoal per ton or quarter.	Value per ton of peat or coke as obtained for coal per ton.	Authorities and approximate accuracy.	Remarks.
Hulme' Canadian Peat Company.	On system of ground for open air.						2,000 to 60 days						Less than 4d. per ton.	30 men	10 per 10 hours		Railway locomotive.				Mr. Allwood and Lieut. Tobin Railway.	Coal six tons cheap to her, made up water four; by operation machines. Water for large tons of coal for peat.
Leavitt's	Air-dried						14 tons daily						4s. (at least)	1	7s. per 10 hours		Sundry				Mr. Leavitt	Not known whether now at work.
Robert's	Air-dried						5,000 to 140 days						4s. to 6s.	1	7s. per 10 hours		Sundry				Mr. Leavitt	Not known whether now at work.
Rye's (on principle of Claudius de Kempler.							24 persons employed.							1	2s. 6d. to 3s.		For charcoal, &c.				Mr. Rye	Invented at an experimental stage; before it reached a result.
Rekdev's	Air-dried				1		1,200 to season	?	?					1								Irish Peat Company, No. 2. Mr. C. Meadows, engineer and reporter.*	Peculiarity—combined with subsequent ascendability of land.
The Palmer of Manufacturers, Manchester's use.	Treated with a solution of lime and air dried.						1,000 to 120 days						Is. 6d. Almost identical as fo.	1	2s. 3s. 3d. to 4s. per 12 hours.	1 to 1½	Boilers, &c., in textile trade work.				Dr. Redwood and Irish Peat Company, No. 2. J. K. C. Meadows, engineer and reporter.*	System much of late still ready for work. Has since been applied to many purposes.
Clayton, Son, & Hutchett's.	Air-dried in several sheds.				25 per cent. more than second time dried, not taken.	75 to 80 per cent.	Estimated at 4,000 (?).						Estimated at 4s. (?)	Three men and four boys to each machine only.			Foundry				Messrs. Clayton, Son, & Hutchett.*	Use of excavating plough proposed. Machinery only a few months in the patent.
Allen's.	Partly air, partly artificially dried. Labour comparatively.						1½ to 2 tons per 24 hours.						10s.	6 men and 4 boys to each machine only.	8s. to 8s. 6d. per 12 hours.		Railway locomotive.				Dr. Rimbault.*	Works belonging to Mabel & Partner, Dr. Redwood, Messrs.
Ryder's	Partly air, partly artificially dried. Labour comparatively.						About 800						Cost 10s. to 12s. per ton.	1	6s. to 8s. 6d. per 12 hours.		Railway locomotive.				Dr. Redwood.*	Works belonging to Mabel & Partner, Dr. Redwood, Messrs.
The Peat Engineering Company, Limited, Dundalk, Ireland.	Air-dried in open air and in covered sheds.				20 per 10 to 12 tons.									1 men and 2 boys to each machine.	5s. 6d. per 10 hours.		Charcoal				Peat Engineering Company, Limited.*	Exhibits Works at Dundalk, also at Limited.
Dumont's, Paris	Air to barge						50 tons	About 15 tons daily.					12s. to 15s. (?)	Twelve	4s. per 12 hours		Charcoal for Paris market.				Irish Peat Company, No. 2. Mr. C. Meadows, engineer and reporter.*	
Dr. Redwood's, at last to Bovigny's.	Air to barge							1,500 tons					Cost of labour alone, in one case, 2s. per cubic yard.	10 men, 12 women, and 4 boys, working per 10 hours.	2s. 6d. to pence per 10 hours.	0·2	Iron blast furnaces.				Here two Mr. Meadows.*	

System or Machinery.	How prepared peat dries.	Area covered by machinery and space for shelter of stacks.	Time occupied in drying. Dependent on favourable weather.	Number of men employed in preparing peat, including cutting, drying, and stacking, &c.	Peat dried per day of 10 hours.	Estimated percentage of loss of peat, dried, in the process.	Approximate loss of dry peat per machine.	Proportion of ash to dry peat, as found by analysis. Proportion of moisture in dry peat as found by analysis. Proportion of moisture in peat as taken in total cost.	Proportion of moisture in peat as taken in calculations, and how obtained, whether by analysis or assumption.	Proportion of ash in peat as taken in calculations, and how obtained, whether by analysis or assumption.	Place peat has to be carried to for burning.	Locality (or area of operations) where machinery is at work.	Estimated cost per ton at works, as delivered on rail, or delivered on board ship, or per cubic or superficial measure.	Total number of men, women, and boys, per machine.	Approximate hours in working day.	Specific gravity of peat when prepared.	Application of peat when produced.	If made into charcoal, coke, or other products, where made.	Local selling price of peat or wood charcoal per ton or quarter.	Value per ton of peat or coke as obtained for coal per ton.	Authorities and approximate accuracy.	Remarks.
Schlickeysen's, of Berlin.	Other air dried. Also dried artificially by means of machinery, which is now abandoned.				25 to 100 tons per day.	10 to 15 tons per day.						Generally by local peat, dried by factory boilers.		By steam power			Sundry				Here Schlickeysen* and others.	Machine usually made of three sizes according to the work required. Each is probably one of the most complete peat-grinding.
Schlickeysen's	As dried				30 tons		6 tons daily					Local labour		By steam power			Glassworks				Here Kahn.*	Works belonging to Siedlung Company.
Rimbault's	In air in barge				Not recorded, but can turn private from observations of case.	5,000 cubic feet, wet.	1,000 tons in 120 days.					By hand labour, aided by a Jacobi's labour.		By steam power			All purposes				G. Rimbault.* Manager of Peat Fuel and Coal Exhibiting Company, Chislehurst.	Two light machines employed on each side of the existing, which are worked by hand. Machine that of Prince of Schwarzenberg.
Allcard's	On Allcard's patented or wire-drawing system of racks.		Wrecked into "cut," the rest in blocks.		1	1	1										Sundry				Mr. E. M. H. Allcard.* Lieut. Tobin, R.E. Irish Peat Company, No. 1. Reported.	
Rolland's	Air-dried			50 per year men.	Rolled into bricks by hand.	Rolled into bricks by machinery.	5,000					By steam-harrier			12 to per cent.		Domestic purposes, and for railway engines.				Prof. O'Reilly.	
Goldberg's	Air-dried on long planks covered with glass frames.		Rolled into bricks by machinery.		About 5 tons per 10 hours.							By hand labour					Domestic purposes.				Dr. Redwood.*	First mechanical work was a commercial success for a little over 20 years.

Written by Mr. Paget.

Also for Dumont's, a letter of commendation from the Paris Municipality, and a certificate of the Paris Municipal Laboratory.

Peat formed by coniferous trees, &c.

By hand, dredged, & pump, and by self-acting machinery.

By hand, dredged, & pump, and by self-acting machinery. Peat formed by coniferous trees, &c.

By hand, dredged, & pump, and by self-acting machinery. Peat formed by coniferous trees, &c.

Peat formed by coniferous trees, &c.

Peat formed by coniferous trees, &c.

SYNOPTICAL TABLE OF DIFFERENT MECHANICAL SYSTEMS OF CONDENSING PEAT ACTUALLY BEING WORKED—cont.

N.B.—HIRSETT-RINE PER CENT. OF THE PEAT USED IS SIMPLY CUT AND PREPARED BY HAND LABOUR.

System or Machinery.	How prepared peat dried.	Area covered by drying ground by months.	Area covered by drying ground by months.	Water pumped by Steam, Horse, or Hydraulic Machine.	Number of men, women, and children employed in working machinery, cutting and pitching peat, shovelling, &c.	Proportion of men, women, and children employed in working machinery.	Approximate number of tons of dry peat produced per machine.	Proportion of bottom as it exists in the moss from which peat is supplied, and proportion of it which is left in the moss as waste.	Proportion of surface of moss cut away and peat or bank removed.	Proportion of surface of moss cut away and peat or bank left as waste.	Does peat pass through machinery or process.	Royalty per ton on peat produced.	Estimated cost of machinery and plant, and of land, and of working.	Price of machinery, waggons, and land, per acre.	Approximate wages to workmen per day.	Specific gravity of peat.	Cost per ton of peat.	Localities and names of purchasers.	If made into charcoal, number of tons per acre of wood.	Local selling price of wood per ton.	Value per acre of land obtained by re-sale of peat.	Localities and names of manufacturers.	Remarks.*
Hydro' Carbon Peat Company.	On the moss, or ground by carts.						1,000 to 40 days						Iron Gun Boiler, 12 to 16 H.P. £1 10s. per H.P.	10 acres	3s. per 10 hours			Railway locomotives.				Mr. Allwin and Lloyd Train Railway.	Good site for drying in hot, moist air moss land; no operative machinery, except for transfer of peat to railway.
Leavitt's	Air-dried						24 tons daily						4s. (at least)	?	7s. per 10 hours			Sundry				Mr. Leavitt	Not known whether now at work.
Robert's	Air-dried						3,000 to 120 days						4s. to 6s.	?	7s. per 10 hours			Sundry				Mr. Leavitt	Not known whether now at work.
Roy's (an artificial drier similar to Hodder's)							15 persons per machine						?	?	7s. 6d. to 8s.			For charcoal, &c.				Mr. Roy	Invented on an entirely new principle; engine & compress still used.
Hodder's	Air-dried			?	?	?	1,200 in season	?			?	?	?	?	?			Domestic purposes	?	?	?	Irish Peat Fuel Company, Mr. J. H. C. Maclean, manager and secretary.	Peat pre-dried by air, and finished by artificial heat.
The Princes of Schwartzenberg, Prince Adalbert's invention.	Pressed into a cylinder and by artificial heat.						1,000 in 120 days						6s. 6d. Always limited at 3s.	Always limited at 3s.	6s. to 6s. 6d., in peat or money, per 10 hours.	1·05		Boilers, &c., in brewers' malt-kilns.				Dr. Buchanan and Irish Peat Company, Mr. J. H. C. Maclean, manager and superintendent.	Steam-dried at kiln and ready for trade. Peat sometimes mixed up charged wood; portions.
Clayton, Sons & Howard's.	Air-dried in ordinary sheds.																	Sundry				Messrs. Clayton, Sons, & Howard.	Use of compressing earth prepared by machinery only a small proportion of the peat.
Abbey's. (Modification of Hodder's, but not yet tried.)	Partly air, partly artificial drying.																	Railway locomotives.				Dr. Rinchardt.	Works belonging to Mr. Abbey's Patent, Mr. Rinchardt, Manager.
Exley's.	Partly air, partly artificial drying.						About 600						Coal 12s. to 15s. per ton.	?	7s. to 7s. 6d. per 10 hours.			Railway locomotives.				Dr. Rinchardt.	Works belonging to the Hyde Ballway Company, Cheshire.
The Peat Engineering and Compressed Fuel Company, Limited. (Exley's system.)	Air dried by open fire and in ordinary sheds.		20 per 6h to 10s. tons.										?	2 men and 2 boys to manufacture.	4s. 6d. per 10 hours.			Charcoal				Peat Engineering Company, Limited.*	Works at Hunwick, also at Sherrod, Shotton valley, Durham, for charcoal trade.
Bisnopth, Paris.	To air in lumps						60 tons	About 11 tons daily.					10s. to 20s. (?)	Twelve	8s. per 10 hours			Charcoal for Paris market.				Irish Peat Company, Mr. J. H. C. Maclean, manager and superintendent.	
Dr. Rinchard's, similar to M. Bisnopth's.	To air in lumps							1,000 tons					Cost of labour alone, in per ton. All charges probably 15s.	10 men, 12 women or children. Also get on moorland.	3s. 6d. to price money per 10 hours.	0·5		Iron blast furnaces.				Mess. Jos. Rinchardt.*	

System or Machinery.	How prepared peat dried.	Area covered by drying ground by months.	Area covered by drying ground by months.	Water pumped by Steam, Horse, or Hydraulic Machine.	Number of men, women, and children employed in working machinery, cutting and pitching peat, shovelling, &c.	Proportion of men, women, and children employed in working machinery.	Approximate number of tons of dry peat produced per machine.	Proportion of bottom as it exists in the moss from which peat is supplied, and proportion of it which is left in the moss as waste.	Proportion of surface of moss cut away and peat or bank removed.	Proportion of surface of moss cut away and peat or bank left as waste.	Does peat pass through machinery or process.	Royalty per ton on peat produced.	Estimated cost of machinery and plant, and of land, and of working.	Price of machinery, waggons, and land, per acre.	Approximate wages to workmen per day.	Specific gravity of peat.	Cost per ton of peat.	Localities and names of purchasers.	If made into charcoal, number of tons per acre of wood.	Local selling price of wood per ton.	Value per acre of land obtained by re-sale of peat.	Localities and names of manufacturers.	Remarks.*
Schlippenbach's of Berlin.	Dried by direct heat. Schlippenbach's machines are mere compounds of the old machines above described.						25 to 100 tons per day.	15 to 20 tons per day.			Generally by hand, but machinery used by Jacob's brother.				By steam power			Sundry				Herr Schlippenbach* and others.	Machine usually worked by steam-engine—smallest may be 4 horses. The site is probably one of the best in Germany for peat.
Schlippenbach's	Air-dried						4 tons daily				Hand labour				By steam power			Glassworks				Herr Kuhn*	Works belonging to Herr Kuhn.
Weidenthal's	To air in lumps						2,000 tons in 150 days.	1,000 tons in 150 days.			By hand labour, aided by a Jacob's ladder.				By steam power			All purposes				C. Schlabach,* Secretary of Peat and Coal Company, working Company's peat bog.	Two light machines employed on each side of the canal, worn in between, similar machines to that of Messrs. Schlippenbach.
Alvesly's	On Alvesly's patented drier, which screens or cuts.			?	Worked by hand "gangs," but not known.	?	?	?	?	?	?	?	?	?	Waterside purposes.			Sundry			Probably 30s. to 40s.	Mr. R. H. Alvesly, Secretary to Peat and Coal Company.	
Bidwell's	Air-dried			24 H.P. portable.	Worked by hand in open bricks.		4000						By a rude drain, and over drier.	Dug up with spades.	Vegetable purposes.			Domestic purposes, for boiling and baking purposes.				Prof. O'Reilly.	
Goldsmith's	Air-dried on long platforms, and finished further				Placed into bricks by machinery.		About 4 tons per 10 hours.				By hand labour				By steam machinery			Domestic purposes.				Dr. Buchanan	Peat undertaking was a commercial failure owing to high cost of production.

Written by Mr. Paget.

Peat dried in the air, and not artificially, is not to be recommended.

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is and must always be, more than when the peat is merely cut. Instead of a pugging mill, we should much prefer to apply a good simple excavating machine. Of course, for the supply of a large town, for instance, condensing has a better field for the reasons we have given. In such a case, or in any instance where a macerator is employed, the most rational plan is to make it portable, as is the case with the oldest and most generally used of the systems appearing in our tabulated statement.

But peat simply cut, whether by machine or by hand, and not condensed, must always remain the cheapest product; and the body of our work contains cumulative evidence to this effect from all the countries where peat is seriously worked and used in large quantities.

The true way of making the peat bogs of Ireland available for industrial purposes in which high temperatures are required, would consist in producing gas from hand-cut air-dried peat, in such furnaces as that of Mr. Siemens, thoroughly condensing the gas, and burning it systematically with its proper allowance of heated air. Used in this way, there is no doubt that common air-dried peat can be made to yield a calorific duty 65 per cent. of that of average Staffordshire coal. Mr. C. W. Siemens has, we believe, proposed that the gas-producing apparatus should be laid down at the bog, and the gas conveyed in culverts to the factory where it is to be burnt. Under the stimulus of the high price of coal, two regenerative gas furnaces have been set up by Mr. A. McDonnell, at the works of the Southern and Western Railway, Inchinore; and they are stated to be already giving good results. In working iron, it is absolutely indispensable either to completely dry the air-dried peat by artificial means, as is done in most of the continental iron-works where the Siemens furnace is not employed, or to gasify it, and condense the gas by injection or surface condensation. This has to be done, not merely to obtain the requisite temperature, but in order to prevent that burning away, or diminution of "the yield" of iron, which takes place whenever heated iron is brought into contact with the vapour of water. An elementary experiment in chemistry consists in producing free hydrogen by the oxidation of heated iron brought into contact with a current of steam.

A cognate apparatus is Hoffmann's continuous kiln, used in such great numbers in the peat districts of Germany, but, as already stated, never even tried in Ireland. A railway running through or near a peat bog would appear to offer a favourable field for the utilization of peat; but, similarly, though the Irish Midland Great Western Railway passes

through 70 miles of bog, the company have not found it to their interest to use peat.

From the examination of experience in other countries, and a consideration of the real value of peat as compared with coal, we have arrived at the following conclusion:—*That peat can only be sold at prices ranging from one-third to one fourth of the local selling price of average coal.*

Now, as the cost of raising coal in (say) South Staffordshire, including all items whatever, except the lordship or royalty paid to the owners, ranges at the most from 5*s.* to 10*s.* per ton, according to the thickness of the seam, the depth, &c.; and as this cost covers both lump and slack coal, a very narrow and impossible margin is left for working peat, except even at remote places where the cost of carriage adds considerably to the price ot coal. In fact, in a large coal producing country like ours, peat would have to compete, not so much with the practically more valuable coal in lumps, but with the much cheaper slack or dust of coal, or small coal, which needs little or no drying, and not much more labour to convert into bricks.

When one bears in mind the high price of labour in Great Britain in relation to a material the varying conditions of which render it impossible to do without some intelligent labour; the inconstant nature of a very moist climate under the influences of which a material containing at least five or six times its weight of water has to be moved and dried; the highly developed means of communication bringing with them almost everywhere a fuel able to do as much work as twice the same weight of peat; that bringing half a ton of this competing coal, a material complete in itself, to the surface, often only costs about half-a-crown and less; it is difficult to hope, in spite of the present high prices of coal, that the production for fuel of peat, *per se*, can compete on a sound basis with the working of coal even at considerable distances from the pit. On the other hand, land and space are extremely valuable, especially in England; wide areas now useless are covered with peat moors, heaths, morasses, and bogs; and if, as in Holland and some parts of Germany, the utilization of peat as fuel were combined with a systematic utilization of the surface and waste left by the extraction of the peat itself, possibly with a simultaneous application of the sewage of large towns, the question of peat and peat wastes might assume a very different aspect. While the extraction of coal generally ruins, by subsidence, the superincumbent land, the extraction of peat often raises its value. The extraordinary prosperity of the peat colonies of Holland and East Friesland is certainly a very important fact, deserving most

careful study. Whether it could co-exist with a relatively low price of coal, or without the conditions of *la petite culture*, where each man is working for himself, are important questions. If we owned a large extent of country covered by peat, we should be inclined to hand over a portion on a 100 years lease to a colony of Dutch; practised in draining and reclaiming such land, and able to teach, by example, the surrounding population. The Dutch realise great wealth out of their peat beds, through their industrious and patient habits; not by means of complicated machinery vainly attempting the impossible task of evolving a rival to coal.

APPENDICES.

TECHNICAL PAPERS ON SPECIAL SECTIONS OF THE EXHIBITION.

(*Contributed by Mr. W. H. Maw and Mr. James Dredge.*)

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The Atlas of Plates referred to in the following Technical Papers, and also in those printed in Volume III., is published by Mr. Charles Gilbert, 37, Bedford Street, Strand. The various Papers are referred to in the Atlas under the following heads:—

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I.	Exhibition Buildings.
II.	Mineral Fuel.
III.	Metals.
IV.	Iron and Steel.
V.	Boilers.
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XII.	Printing Machinery.
XIII.	Sugar Making Machinery.
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TECHNICAL PAPERS ON SPECIAL SECTIONS OF THE EXHIBITION.

(Contributed by W. H. Maw and James Dredge.)

MINERAL FUEL.

As the wealth and production of mineral fuel which a country possesses may be taken as a fair standard by which its present and future industrial and commercial development can be gauged, it is of no small interest to compare the data upon this subject offered by the Exhibition at Vienna. It will be valuable therefore to review the collections of mineral fuel as they were represented by the different countries; and especially suitable to commence this series of reports by such a review, as upon the production of mineral fuel manufacturing power so largely depends.

Great Britain.

Beginning with Great Britain, we looked vainly for any representation of her coalfields. Though it could not be well expected that she should carry coal in large quantities to the Vienna Exhibition, it might at least have been supposed that a comprehensive geological, statistical, and graphical description of her coalfields, the annual production, consumption, and export of coal, &c. would have been furnished either by the Geological Survey, by the Government inspectors of mines, or by the Government School of Mines in London; such a representation, by the side of those made by other countries, would have impressed at a single glance even the indifferent visitor with the vastness of that mineral wealth to which Great Britain so largely owes its political, social, and commercial power and prosperity. Instead of this, a few insignificant specimens of coal from the South Wales basin, showing the steam coal of Abergorki, and of the upper four-foot seam at the Aberdare colliery, together with a couple of examples of fibrous coal and some fossils, completed the representation of British mineral fuel. Rather than make so poor a show, it would have been almost better not to have exhibited at all.

France.

France, which possesses the very important coal basins of the Loire, the Centre, and the Nord, and whose annual output of coal is something like 16,000,000 tons, was no better represented. The only societies exhibiting were the Mines la Grand-Combe, in the Gard Department, and Schneider and Co., of Creusot, both of which showed fair samples of coal and coke; and a firm in Algiers contributing a sample of lignite from Oued Zavnia. The Grand-Combe Coal Company produced also plans and sections of their mines, buildings, &c.

Spain.

Looking at Spain, the variety of mineral fuel, both real coals and lignite, or brown coal, was somewhat surprising. The former are derived from the great coal basin of Asturias, from that of Andalusia, and from the neighbourhood of Burgos, in the province of Castilia; the latter come from Logrono and the Balearic Islands. The annual production of coal in Spain scarcely exceeds 600,000 tons, but coal mining in that country, particularly in the coal basin of Cordoba, would have a great future, if Spaniards, as a rule, did not make such very indolent workmen, and if Spain could get rid of her perpetual political quarrels. Good specimens from the northern coal basin were shown from Oviedo, Santander, and the gun foundry of Truvia, while

others came from the Andalusian basin, from Cordoba, Sevilla, Panada, &c. The coal from both basins makes a good coke, and, considering the wealth of Spain in rich iron ore, we see great natural opportunities for iron manufacture on a large scale present themselves. Tertiary coal is found in numerous localities, such as the Isle of Palma, Logrono, Catalonia, Teruel, Albacete, and others.

PORTUGAL.

The other country occupying the Iberian Peninsula—Portugal—is not favoured with mineral coal, and it only contributed to the Exhibition a specimen from San Pedro da Cova, which seems to belong to the tertiary formation.

ITALY.

Italy, which is also poor in mineral fuel, showed samples of anthracite from Aosta, in Lombardy, but with no coal belonging to the coal measures proper, though it cannot be contended that these coal-bearing strata are altogether non-existent in Italy. Very good black tertiary coal was, however, shown from the island of Sardinia, particularly from Fontanamare, near Cagliari, and from Gonnesa, where over 10,000 tons are raised annually; brown coal and lignite from Calizzano, near Savona, Monterufuli, near Pisa, Cavriglia, in the upper valley of the Arno (where also 10,000 tons are produced per annum), Avellino, and other places. Lastly, Sicily, which has hitherto been considered without mineral fuel, exhibited lignites from Nicosia, Catania, and Messina, which ought to be used in the refinement of sulphur, instead of that mineral itself, which is now employed as a fuel for the purpose.

SWITZERLAND.

Switzerland, which only possesses a few beds of brown coal, and is dependant for the supply demanded by her ever-increasing industry upon her neighbours, Germany and France, exhibited no coal, only some specimens and a large pyramid of natural asphalte from the asphalte mines of Val Travers in Neufchâtel.

BELGIUM.

Belgium, whose annual output of first-rate coal from the basins of Liége, Charleroi, and Mons, is something like 19,500,000 of tons, giving occupation to about 100,000 men, showed very little of her mineral treasure. Felix de Haynin and Co., of Marcinelle and Gosselie, A. Godin, of Jemappe, the Espérance Company, and John Cockerill and Co., of Liége and Seraing, were the only exhibitors of samples of coal and coke; the average value per ton being 30 francs for the former, and 60 francs for the latter. However, some good models and drawings of machinery for coal mining were contributed by Theophile Guibal, Nicolas Libotte, Frederic Nyst, the Hasard Coal Company, of Micheroux. Geological maps by Professors De Konink and G. Dewalque, of Liége, and a statistical and graphical representation of the production, consumption, and transport of mineral fuel, by the Ministry for Public Works, completed the exhibits for this country.

HOLLAND.

Holland, though it possesses a small part of the German coal basin of Aachen, showed nothing, and Denmark only some samples of coal belonging to the lias of Bornholm. Sweden, however, made a great show of her little coal basin round Helsingborg, in Skane, which belongs likewise to the lias formation, and only contains seams of insignificant value. The Wallakra and Kropp Companies both exhibited samples from their mines.

GERMANY.

The German Empire comes next under consideration, and in and near the two great pavilions numerous exhibits of mineral fuel were met with. Germany owns a great many coal deposits, some of which, as those of Aachen, of the Saar Valley, of Westphalia, of Zwickau, and of Upper Silesia, rival with the largest coal districts of this country.

In 1870 the German Empire raised no less than 34,000,000 tons of coal, though the output was much depressed by the Franco-German war in the second half of that year; 941 coal mining associations employed 146,000 miners, and produced coal worth about 10,000,000*l.* at the pit's mouth. Although no exact figures are yet published for the year 1372, the total output can be safely estimated at 50,000,000 tons, worth 15,000,000*l.* at the pit's mouth, as the price of coal has since then increased 50 to 70 per cent., and even more, and the year 1872 was one of unprecedented prosperity.

The mineral exhibits of Germany were well explained by the representations of the Imperial Geological Survey of Prussia, Baden, and Bavaria, showing general maps and also maps of special coal basins, with sections laid through them, and by those of the Prussian Ministry of Commerce and Public Works, giving detailed statistical information on all matters connected with mining, and providing large-scale tables and diagrams, which at a glance gave any required details as to quantity, consumption, and movement of the minerals raised. It will be convenient here rapidly to review the exhibits of the various German coal basins, beginning at the Belgian frontiers, where the coal basin of Aachen forms the eastern continuation of the coal measures of Liége. This basin is broken into three large divisions by two great faults, called Munstergewand and Sandgewand, which cause vertical dislocations of above 60 fathoms, and by which the coal seams are bent and broken in so singular a way, that their northern wings, or so-called uprights, stand nearly vertical, while the southern wings or flats, dip at an angle of only 30 deg. The basin contains in its southern part, 45 seams with 60 ft. of coal; in its northern part, near Hongen, 25 seams with 42 ft. of excellent coal, which may be used for all purposes. The chief exhibitors from this coal basin were the Wurm Union Company, the Eschweiler Mining Company, the Aachen-Hongen Coal Company, and Edward Honigmann, representing collectively an annual output of about 3,000,000 tons. The coal is of superior quality, suited for gas, metallurgical, and steam purposes, and is largely exported.

We come now to the basin of the Saar Valley, which covers an area of over 600 square miles, of which, however, only a section of about 90 square miles belongs to the productive part of the coal measures. These strata are naturally divided into three layers; the lower, with a thickness of 460 fathoms, contains 64 seams with 146 ft. of coal; the middle, within 840 fathoms of rock, 86 seams with 149 ft; and the upper story of 320 fathoms, 14 seams with 43 ft. of coal. The aggregate thickness of coal is thus 338 ft., divided between 164 seams, of which number, however, only 77 with 240 ft. of coal are about 2 ft. thick, and considered profitable; these contain, to a depth of 300 fathoms, a quantity of 2,750 millions of tons. During the year 1872 nine mines were worked in this basin by the Prussian Government, and 4,200,000 tons of coal, raised by about 20,000 men, 202 steam engines of 8,600 horse-power, 3 water columns, 6 compressed air engines, 336 steam boilers, and 425 horses.

The Saar coal is largely exported to France, South Germany, Switzerland, and even special coal trains are sent every week thence over the Brenner Pass to Italy. Coal-mining in this district dates from 1586; however, the first regular adit mine was only commenced in 1754, the first steam engine erected in 1828, and compressed air machinery introduced in 1867. The quality of the coal varies; in the lower stratum it is bituminous caking coal; in the middle, steam coal, burning with a long flame; and in the upper region it consists of a somewhat meagre and anthracitic kind of coal, which, however, is very useful for domestic purposes. In the form of a large trophy, the Government administration of Saarbruck exhibited coal and coke from the Kronprinz, Prinz Wilhelm, von der Heydt, Dudweiler, Sulzbach-Altenwald, Reden, Heinitz, Koenig, and Friedrichsthal mines. The Hostenbach private coal mine also showed samples of good coal. Some of the mines are provided with coke ovens on the latest and most improved systems, such as Appolt's, Koppe's, and others.

The basin of the Saar continues towards the north-west into Lorraine, where it is covered by a thick layer of new red sandstone, under which, however, collieries are worked at Spittel and Carlingen, near Forbach, while towards the south-east it stretches into the Bavarian Palatinate, where about 300,000 tons of coal are annually wrought near St. Ingbert.

If we now follow the valley of the Rhine, we enter, near Düsseldorf, the great coal basin of the Ruhr, or of Westphalia, which covers an area of over 1,000 square miles; here in its southern part the coal-measures crop out to the surface, while towards the north they are covered by an ever-increasing thickness of cretaceous strata. Only towards the north-east, near Osnabrück and Ibbenbüren, do they come up to surface from under the Permian formation. Here, again, three divisions may be distinguished, of which the lowest contains coal beds of a anthracitic, meagre character, while the middle is composed of caking steam coal, and the upper of highly bituminous gas coal. In the western part of the basin 83 seams with 173 ft. of coal are explored; in the central part, 70 seams with 121 ft.; and in the eastern part 81 seams with 154 ft. of coal are known, while a still greater number may be expected towards the north. The quantity of coal which has hitherto been explored, is computed—to a depth of 200 fathoms—to be, upwards of 333,000 million tons, of which 225,000 millions belong to the upper and middle divisions. The total produce of coal from this important coal basin was upwards of 14,000,000 tons in 1872, raised by 68,000 men from 340 collieries. The exhibits of the district were collectively represented by 92 mines, which showed coal and coke, while 12 others exhibited black band and clay ironstone from the coal measures.

Leaving out such small coal deposits as those of Berghaupten on the western slope of the Black Forest in Baden, Miesbach, in Bavaria, Ibbenbüren, in Westphalia (which is, however, calculated to contain over 100 million tons), Piesberg, near Osnabrück, Stockheim, on the south side of the Thuringian Forest, Ilmenau, on its northern slope, Ilefeld, on the south of the Hartz mountains, as well as the, geologically speaking, more recent formations at Minden, Bohmte, Bückeburg, Oberkirchen, and Osterwald, which belong to the Wealden clay formation, we meet with a larger basin again in the lower valley of the Saale, near Halle in Prussian Saxony, where, at Wettin coal has been worked since 1583, the present mines producing about 200,000 tons per annum.

If we follow the valley of the Elbe upwards in the kingdom of Saxony, we meet with two minor coal basins near Dresden, at Plauen and Oschatz, before we reach the important coalfields of Zwickau, on the northern slope of the Erzegebirge. Here, by about 70 collieries and 13,000 men, three million tons of coal are annually raised. The coal is of excellent quality, and is extracted from a basin which covers an area of 150 square miles, estimated to contain as a minimum 800 million tons. Though the mines of this district are worked at a considerable depth, they belong to the best paying collieries of the Continent, and amongst them the Erzgebirge Coal Association has yielded dividends of 160 per cent., the Zwickau Burgher Company 140 per cent., the Zwickau Coal Company 98 per cent., the Zwickau-Oberhohndorf Company 54 per cent., and so on.

We turn next eastward, and enter the coal basin of Lower Silesia, near Waldenberg, which contains twenty-seven seams of superior caking coal 102 ft. thick. Its annual produce from about thirty mines is two million tons, raised by about 10,000 men. There were ten exhibitors from this district, who showed, in a fine trophy of coal and coke, samples of their produce. This same coal basin continues over the Austrian frontiers into Bohemia, where coal mines are also worked near Schatzlar and Schwadowitz. The great coal basin of Upper Silesia is not confined to Germany, but extends also into Russian Poland and the Austrian provinces of Gallicia, Moravia, and Silesia. This district occupies on German territory a surface of 190 square miles, containing over fifty coal seams, of an aggregate thickness of 333 ft., of which number thirty-five seams, 283 ft. thick, are worked profitably. The contents of this enormous deposit are calculated at 250,000 million tons, and seams of a thickness of from 30 to 50 ft. are not uncommon, such as the celebrated so called Fanny, Gerhard, and others.

In 1770 no coal mine existed in this district. At present more than 10 million tons are annually raised from over 90 mines by about 30,000 miners. At the Exhibition some 30 firms and mines were represented by samples of their coal and coke, several of the collieries being of great importance. Königsgrube raises annually one million tons with 3,000 men; Luise, 700,000

tons with 2,500; Laura, 300,000 tons; Hedwigwunsch, 250,000 Hohenlohe, 450,000, &c. The quality of the coal differs with the localities. At Zabrze, on the western side of the basin, the coal is bituminous gas coal; towards the middle, near Königshutte, it loses its caking properties and becomes dry steam coal, and at the eastern side, near Laurahütte, it is almost anthracitic.

Before leaving the German Empire we may be allowed to say a word about the tertiary brown coals and lignites which are found in vast deposits in the country. They form the extensive tertiary basins, which belong to the oligocone, or miocene periods, of the Lower Rhine, near Bonn, of the Westerwald, of the Wetterau, Vogelsberg, and Habichtswald, in Hesse-Cassel, of Thuringia, of Magdeburg, of Brandenburg, of Silesia, of the Oder and Vistula, and of the Bavarian Alps. The quantity of tertiary coal raised since 1816 has increased from 150,000, to over nine million tons in 1872. The brown coal is used for steam and all industrial purposes; near Magdeburg, it is the only fuel for the very extensive beet-sugar manufactory of that district, and in Thuringia it offers the raw material for a production of paraffine and mineral oils on a very large scale.

Austria.

We come next to the Austro-Hungarian empire, and a key to its mineral wealth was found in the exhibits of the Imperial Geological Institute, of Vienna, and in those of the Royal Hungarian Geological Institution, of Buda-Pesth. The former, which has existed twenty-four years, has carefully explored the greater part of the monarchy, and is still publishing the results of these researches in the form of geological, general, and special maps, as well as in numerous publications, of which the Year-Book is the principal. This Institute exhibited a very complete collection of the mineral fuels of Austria, illustrated by maps and geological sections, and arranged after the geological formations in which they are are found. The Hungarian Institution, which owed its existence in 1869, to the political separation of Hungary from Austria Proper, exhibited a similar collection of Hungarian coals in the department of that kingdom. A glance at the two collections showed at once, that by far the greater number of samples belong to more recent formations than that of the real coal measures, and that the latter are confined to a few parts of the empire only. In the statistical and graphical explanations, which were given by the Imperial Ministry of Commerce and Agriculture, all kinds of coal, which belong to the tertiary formation, though most of these are black, are classed as brown coal, while all others are termed black coal or stone coal, comprising thus samples from the coal formation proper, the Permian, the Lias, and the Cretacean systems.

Official publications show that in Cisleithan Austria, the production of coal of all kinds has increased from 1,843,000 tons in 1855, to 8,575,000 tons in 1871. The quantities raised in the different provinces are very unequal, as will be seen from the following list:—

	Black Coal.	Brown Coal.
Bohemia - - -	50 per cent.	56 per cent.
Silesia - - -	23 „	—
Moravia - - -	11 „	3 „
Galicia - - -	5 „	—
Other provinces - -	2 „	—
Styria - - -	—	25 „
Austria - - -	—	8 „
Carniola - - -	—	4 „

These figures show the great advantage in these special resources which the northern provinces possess over the rest of the empire.

Beginning with Bohemia, we find two small basins of anthracite near Brandau, in the Erzgebirge, and near Budweis in Central Bohemia, both of little importance, followed by the important coal basin of Kladno-Schlan-Rakonitz, to the west of Prague, which produced in 1871 nearly 1½ million tons of good black coal. It extends from Kralup, on the Moldau, westward over 32 miles, and makes a turn southward for 10 miles, with an average

width of 3 to 4 miles; it stretches probably much further to the north-east, where it underlays the strata of the Permian and Cretaceau systems. This basin forms again two natural divisions; the lower, resting upon Silurian rocks, contains two principal coal seams, the bottom seam 9 to 18 ft. thick, and the great seam which is 30 to 36 ft. thick, and beats the 10 yard coal of Dudley. The principal pits are near Kladno and Brandeisl, and belong to the Emperor Ferdinand, the State Railway Company, and the Prague Iron Company; the deepest is the Kubek shaft of the State Railway Company, with a depth of 184 fathoms. The district employs about 8,000 miners underground, and owns over 20 winding engines, and as many pumping engines of from 50 to 450 horse power. The upper division of the measures covers an area of 300 square miles, and contains only one coal bed of 20 to 40 in. in thickness, at an average depth of 30 to 40 fathoms, which in 1871 yielded about 125,000 tons from about 90 small pits. South-west of this is the Pilsen coal basin, forming an oval of about 250 square miles, which, however, is not yet sufficiently explored. On its northern border it contains only one seam of 7 ft., on the south side five from 7 to 64 in., east three beds, 32, 47, and 20 in. thick; while near Littiz, on the south-east side of the basin, three beds are again known, of 18, 42, and 84 in. in thickness, at a depth of from 80 to 100 fathoms. On the whole the formation is rather irregular, and its yield in 1871 was only about 220,000 tons, raised with 28 winding and 25 pumping engines, with respectively 423 and 1,393 horse power. The coal of the southern part makes very good coke, and contains about 6½ per cent. of ashes on an average. Four other small basins, namely, those of Radnitz, Miroschau, Wittuna, and Manetin are of little importance, and need only be mentioned here.

The Schatzlar-Schwadowitz basin, on the western slope of the Riesengebirge, is the continuation of the Waldenburg basin in Silesia, already mentioned. It contains over 20 seams, of which however only 15 are profitable, and contain for the most part a very good kind of coal. Their yield was near Schwadowitz, 80,000, and near Schatzlar 140,000 tons, raised by 2,000 men and 20 steam engines.

The very important deposits of tertiary brown coals or lignites of Bohemia, have next to be noticed. They are five in number. The Eger basin contains a seam of from 2 to 6 fathoms in height, being partly worked open-cast, partly underground. The Falkenau-Carlsbad basin stretches nearly 20 miles from S.W. to N.E., with an average width of 4 miles, and contains at the bottom two beds of brown coal 5 fathoms thick, and in some parts a considerable seam of lignite of from 4 to 16 fathoms in height. Both are extensively worked, and about 2,500 men raise 80,000 tons of lignite and 240,000 tons of brown coal per annum. The most important—the Saatz-Teplitz basins—employs 6,300 men, and produces about 2 million tons, which are for the greater part exported to Germany. The coal comes from one seam, which is, on an average, 5 fathoms thick, but varies from 3 to 14 fathoms, as near Dux and Bruex. The principal exhibitors in the joint collection of the Bohemian coalowners from this basin were the Dux-Bodenbach Railway Company, Prince Clary, Counts Westfalen, Nostiz, and Salm, and others. The quality of the coal varies, as may be expected, according to its amount of moisture and ashes; however, the expenses of raising are very small, only 5 to 8 kreutzers per hundredweight, or about 2*s.* to 2*s.* 4*d.* per ton, and the price is 4*s.* and 6*s.* per ton at the pit's mouth. The Zittau coal basin in northern Bohemia comprises five smaller secondary basins with several coal beds, which produce about 800,000 tons, and the Budweis basin in the south, still less.

The chief part of the coal obtained in the provinces of Moravia, Silesia, and Galicia is raised in the coal basin of Ostrau-Karwin, on the borders of Moravia and Silesia, which forms the southern outcrop of the extensive coal measures of Upper Silesia before mentioned. It covers an area of over 160 square miles, and has millstone grit and culm shales as underlying strata; the coal measures proper, however, are known to contain no less than 370 coal seams, from 5 to 12 ft. thick, of which number 117, with an aggregate thickness of 338 ft., are considered profitable. Coal mining in this district commenced only in the middle of last century, and at the present time 61 pits have been sunk of which the deepest has reached 160 fathoms from the surface, and

10,800 workmen raised from these pits, in 1871, 1¼ million tons of excellent bituminous coal, which is largely exported to Vienna and the rest of Austria. The principal exhibitors from this district were Baron Rothschild, Prince Salm, Archduke Albert, Counts Larisch and Wilczek, and the Emperor Ferdinand Railway Company.

Towards the north-east of the one last mentioned, we meet with another outcrop of the great Silesian coal basin near Krakau, in Galicia, where it again covers an area of over 150 square miles, and contains, near Jaworzno, thirteen coal seams 100 ft. in thickness collectively, and of which the Jacek seam is 26 ft. in height. This district will gradually become of extreme importance to Austria, but it is not nearly so extensively worked as it ought to be, for in 1871 it only produced about 250,000 tons with 2,300 men and 40 steam engines. The exhibitors of coals from this district were Count Potocky, the Jaworzno Company, and the Ferdinand Railway. A third coal basin is that of Rossitz-Oslawan, in Moravia, about 14 miles west of Brünn; it has no connexion with the former, and only contains three coal beds 26 ft. to 30 ft. thick in the aggregate. Here, six companies produce about 300,000 tons annually with 2,300 men; the coal is very bituminous, and yields 77 to 78 per cent. of coke. We may mention here as a curiosity, the existence of coal-bearing strata in the chalk formation of Moravia, at Uttigsdorf and Johnsdorf, though the seams are small, and rather impure, and their annual yield insignificant. Brown coal is also found in this part of Austria, north of Lundenburg, where a basin with one or two seams of lignite covers about 200 square miles, and 100,000 tons are raised for the consumption of some beet sugar manufactories. Another deposit of tertiary coal is met with in Western Galicia, near Grudnadolna, where a bed of 4 fathoms is found with Eocene clay, and in the eastern part of that province, near Zolkiew and Kolomea, where lignite is raised for the use of sugar factories and the town of Lemberg.

Turning next to the Alpine provinces of Austria, we find coal exhibits from Upper and Lower Austria, Tyrol, Carniola, Styria, Carinthia, Istria, and Dalmatia, of which the joint produce of mineral fuel in 1871 was about 50,000 tons of black coal, and 1⅞ million tons of tertiary brown coal and lignite. These figures show at once that the younger species of coal are by far predominant in the Alpine regions, and though they are of excellent quality as an ordinary fuel, they are deficient in coking qualities, and therefore not fit for use in blast furnaces. This is very much to be regretted, as these districts are blessed with enormous riches of first-rate iron ores, which now only can be utilised either by using wood charcoal as fuel, or by exporting them to places where mineral coal and coke can be had. This is actually done by the Great Innerberg Company, of Styria, who send their ironstone to Schwechat, near Vienna, where it meets the coke from Moravia.

If we first look at the localities where black coal is raised, we find, stretching along the northern slope of the Norian Alps, from Wiener-Neustadt to Steyer, the strata of the Lias, in which partial basins are filled by younger deposits belonging to the Cretacean period, and embracing particular carboniferous strata of the middle Cretacean or Gosau formation. Such small Cretacean basins are found west of Wiener-Neustadt, near Neunkirchen, Baden, Kirchberg, Lilienfeld, Hainfeld, Gaming, and Amstetten, in Lower Austria, and at Weyer, in Upper Austria. Although their total output of coal is hardly more than 100,000 tons a year, they are still of considerable local importance, as they supply numerous smelting and other works with a very good fuel. The coal from this district cokes well, which the younger tertiary coal does not, and they yield from 64 to 66 per cent. of good coke, with an amount of 5 to 10 per cent. of ashes. At Grünbach, near Neuenkirchen, occur 20 seams of more than 20 in. thickness, some of them even of 60 to 72 in., and in the collieries of Mr. Drasche 3,000,000 tons are prepared for extraction, at Lilienfeld 1,000,000, and smaller quantities at Hollenstein, Pamreit, Lunz, and Pechgraben, near Steyer, on the Enns river. An insignificant deposit of anthracite, belonging to Prince Schwarzenberg, is found near Turrach, in Styria, this belonging to the real coal measures. It is used at the blast furnaces of Turrach.

When we follow the Danube valley upwards from Vienna, we find several

tertiary basins containing brown coal and lignite at Hart, near Gloggnitz, at Grillenberg, near Pottenstein, and Thallern, near Krems; their total produce, however, exceeds hardly 60,000 tons per annum, and the chief mine proprietors of the district are Prince Lichtenstein and Mr. Drasche. Another brown coal district is in the Hausruck Mountains, at Wolfsegg-Traunthal, where over 250,000 tons are annually raised by 1,000 men. The coal comes from an upper bed of 13 ft. and a lower one of 7 ft. thickness, and is used by the locomotives of the Empress Elizabeth Western Railway. The rest is used by the Imperial Salt Works and the manufacturers of Upper and Lower Austria. The proprietors are Josef Werndl and Co. A few brown coal beds are also found in the Tyrol at Häring, near Innsbruck, Wirtatobel, near Bregenz, and at Strigno and Bretonico, in the Trentino. The most important is the first, where a bed, 5 fathoms thick, of excellent black pitch coal is worked for the use of the Imperial Salt Works at Hall, and for some cement works.

Looking now at the southern provinces of the empire, we meet with important collieries in Carinthia, near Völkermarkt, Klagenfurt, Villach, St. Veit, and Wolfsberg. The coal formation is here again Miocene, and contains beds of lignite, 12 to 18 ft. thick, with an amount of ashes varying from 6 to 12 per cent.; it is, however, consumed with advantage at the iron and steel works of Praevali, Streiteben, and some other works, the total output being about 80,000 tons. Next to Bohemia, it is Styria which furnishes the greatest amount of mineral fuel, and it is here that we find in the valleys of the Mur river and its tributaries the greatest coal deposits. They belong likewise to the Miocene formation, and furnish a most excellent black glance coal near Judenburg, Leoben, and Bruck, and very good lignite at Illach, Wartberg, and Parschlug.

The mines of the Styrian Iron Company at Johnsdorf, near Judenburg, stretch over a distance of 7 miles, and contain one big seam of 15 ft., below which two smaller beds occur occasionally. The coal contains from 1½ to 12 per cent. of ashes, and is consumed at the Zeltweg puddling works. A great basin of tertiary strata stretches north of Leoben to a distance of 2,000 fathoms, and 700 fathoms wide; it contains an excellent coal bed, which reaches up to 6 fathoms in thickness, and is worked partly with adit levels, partly with shafts, by the Innerberg Iron Company and Messrs. Fridau and Drasche. The coal is screened and partly washed, and contains only 3 to 5 per cent. of ashes. The same seam is also worked at Urgenthal and Parschlug, near Leoben, but it is thinner, though of good quality. Another important coal deposit is that of Köflach and Voitsberg, westward of Graz, which covers an area of 16 square miles, and in 1871 yielded about 500,000 tons of a dark lignite, with 1½ to 10 per cent. of ashes. The height of the coal seam reaches from 12 to 20 fathoms, or from 96 ft. to 120 ft., but in some parts it is only 1½ to 2 fathoms. It is worked opencast at Lankowitz, Pichling, Roshenthal, Mitterdorf, Kainach, and underground towards the centre of the basin, the chief owners being the Vordenberg-Köflach Mining Company, Reiningshaus Brothers, the Kainach and Voitsberg Coal Companies, and others. South from this basin another rather important locality is near Wies and Brunn, where three seams of very good glance coal are worked—these varying from 4 ft. to 16 feet—and at Eibiswald, where the coal is 12 ft. thick. This latter coal is consumed at the Eibiswald Iron Works. We now come to the coal mines of Lower Styria, which are worked in the lower Miocene, and contain brown coal, which partly cokes. At Buchberg the seam is 4 fathoms thick, of which, however, only the upper 12 ft. to 14 ft. are profitable for working; at Tüffer it is nearly 6 fathoms, at Hrastnig 12 fathoms, and at Trifail 20 fathoms thick. The seam contains black glance coal, but its lower banks are much mixed up with shale, while the higher parts are clean. About 300,000 tons are raised here collectively by a great number of coal proprietors. Leaving Styria, we find the brown coal basins to continue in Carniola, where, in 1871, about 150,000 tons were produced. The principal mines are at Sagor, where a coal bed, 5 to 20 fathoms thick, is worked after a peculiar method, the bed being inclined from 50 to 70 deg. The coal is black glance coal, with only 6½ per cent. of ashes. The mines next in importance are those of Mr. Kuschel, near Johannesthal, which furnish the fuel

for the spelter works of the neighbourhood from a seam 2 to 5 fathoms thick. In Istria it is the coal basin of Carpano, with an annual production of 40,000 tons, and in Dalmatia that of Monte Promina, near Siverich, and Dubbravizza, near Scardona, which deserve to be mentioned. The Monte Promina seam is only 6 ft. thick, but of very good quality; it yields 50 per cent. of coke, and is consumed by the Austrian navy.

Having reviewed the coal deposits of Cisleithan Austria, we come next to look at those of Hungary and Croatia.

The coalfields of Transleithan Austria, namely, Hungary, Croatia, and Transylvania, are also scattered over a great area, and consist principally of tertiary deposits, though older formations containing coal-bearing strata are not excluded. Of these latter we find a small carboniferous basin belonging to the Keuper formation in the upper valley of the Neutra river near Handlowa and Kostolan, from which localities Count John Pallfy exhibited some interesting specimens, and a similar though smaller deposit of coal is known somewhat southward at Obitz, near Aranayos Marotsh. One of the most important colliery districts of Hungary is that of Fünfkirchen, which is situated in the corner between the Danube and the Save river. From here numerous exhibits of coal were sent by the Hungarian Steamship Company, the Danube Steam Navigation Company, the Varallja Coal Company, and others; the annual production of an excellent kind of coking bituminous coal is computed at about 150,000 tons. This coal formation is the Lias, which is composed of sandstone and shale, containing about 25 coal seams, some of which are several fathoms thick. It stretches north-east of Fünfkirchen, and near Szaboles, Samogy, Vassas, Pecsvar, Nadasd, and Varallja the coal measures come partly up to the surface, while they are partially covered by Jurassic limestone and some tertiary strata. This coal is of the utmost importance for the steam navigation of the Danube, and large trophies of it, and of coke and patent fuel made from it, were exhibited by the Danube Steam Navigation Company. Other important deposits of older coal formations are found in the Banat, near Raschitza and Oravitza, where extensive collieries are worked by the Austrian State Railway Company. The real coal measures are found here near Reschitza, extending over the neighbourhood of the Berzawitza valley, and containing at Szekul four profitable coal seams of $2\frac{1}{2}$, $5\frac{1}{2}$, 5, and $5\frac{1}{4}$ ft. thickness. Though the coal is of good quality, the beds are often divided into strata by interpositions of black band and shale and only 60 per cent. of their bulk is considered to be coal. The coal measures are covered by red sandstone, and the latter by strata which belong to the Lias, and are carboniferous at Doman and Reualb, where two seams of good coal, 6 and 4 ft. thick, are worked. The output in 1872 was over 50,000 tons. The same formation is found at Steyerdorf, near Oravitza, resting upon red sandstone, and containing five seams of 6, $4\frac{1}{2}$, $4\frac{1}{2}$, 9 to 12, and $3\frac{1}{2}$ ft. respectively; it extends over 6 miles in the direction from N.N.E. to S.S.W., and is one mile wide. The coal is black, cokes well, and gives 64 per cent. of hard coke with 8 per cent. of ashes. It is used at the smelting works of the company. The produce in 1872 was somewhat over 180,000 tons. Carboniferous strata of Lias are also found at Szaszka, Isvorlung, Mehadia, Orgaschu, Rudina, Drenkowa, Eibenthal, and Plavisevica, south-east of Oravitza.

Having done with the older coal deposits we shall now look at the Tertiary basins of Hungary, which, as a rule, contain black glance coal and lignite of excellent quality,

On the southern slope of the Carpathian mountains, which are chiefly composed of Cretacean sandstone cliffs, we meet with a few unimportant Miocene coal deposits at Tordosin and Lissek, north of Ruttek, in the upper Arva valley; again, at Leutschau, Banska, and Milhalovce, north of Kaschau, and near Karva and Huszth, in the Marmaros; likewise at Avas and Nagy Banya. Of the greatest importance, however, is the central basin north of the Matra and Buk mountains, which is traversed by the Zagyva river and its tributaries. This basin is filled and surrounded by trachytic tufas, which themselves are covered again by Miocene strata, containing from one to three beds of excellent black glance coal. Such is the case west from

Miskolcz, at Arlo, Varkony, Bator and Dios Györ. At Varkony the coal is 20 ft. thick, and at Dios Györ 8 ft. The most important deposit is that of the Zagyva valley, between Kis-Terenne and Kis-Arany, which is intersected by the Northern State Railway. Here are three seams, with about 24 ft. of coal, worked at Matra-Novak, Matra-Szele, Kis-Terenne, Salgo-Tarjan, and Kazar, which yield about 300,000 tons of first-rate tertiary coal. The principal exhibitors were the Salgo-Tarjan and Kis-Terenne coal companies. Extensive coal fields are also opened here by the Anglo-German Bank, of Hamburg. Some minor basins exist north of Balassa Gyarmath, at Ovar and Zelli, and south of that place at Nemety and Gödollö, near Pesth. Another important coal district is that of Gran, on the south side of the Danube. Here a seam, three to four fathoms thick, is worked; it is sometimes split in two or three beds, when their accumulative thickness rises to about five fathoms. Such is the case near the Gete mountains, at Dorogh, Tokod, Bajot, Neudorf, Annathal, and Csolnok. The coal belongs to the Eocene formation, which is, however, covered by Miocene strata, with two other small seams. The basin is estimated to cover an area of about 300 square miles, containing 5,000 million tons. The annual produce is, owing to the want of good communication, only about 100,000 tons. Between the coal basin of Gran and the Great Balaton lake, brown coal is known at Zsemlye, Csernye, and Papa, and only worked on a small scale. But a very large deposit exists at Brennberg, near Oedenburg, west of the Neusiedel lake. Here a bed of from 60 ft. to 120 ft thick is worked extensively, and yields a very good black glance coal. A similar fuel, partly mixed with lignite, is found at Zillingdorf and Potsching, and a little south, at Sinnersdorf and Pinkafeld, and again south-west of Warasdin, beds of lignite and glance coal occur near Ivanec, Pleinenseino, Granec, and Krapina; the mines at the latter places are, however, insignificant, and they wait for a better opening by new railways.

We have next to cast a glance at the beds of mineral fuel found in the provinces of Croatia, Sclavonia, and the military frontier. In the vicinity of Agram, we meet first with the Tertiary formation of Samobar and Bregana, west of that town. It contains a considerable seam of very good lignite, which is worked for the glass works of the neighbourhood. South-east from Agram are the coal basins of Ivanec and Kravarsko; at the former is the brown coal, 5 ft. to 18 ft. thick; in the latter are found two seams of 10 ft. and 3 ft., which contain a coking kind of lignite-like brown coal. In Sclavonia, near Pozega, a seam of black Eocene pitch coal, 24 ft. thick, at Bogdan, one 12 ft., and at Gradistje, one of 12 ft. thickness, are known to cover a considerable area. The time has not yet come to extract these mineral treasures with profit, for the want of industrial establishments in these regions. The same holds good for the brown coal mines at New Gradiska, Malino, and Ciglenik, where six seams, 6 ft. to 8 ft. thick, containing over 900 million tons are sunk through. Exhibitors from these provinces were the Ivanec, the New Gradiska, the Petrovagora, and Radoboy coal companies, and Messrs. Popovits, Steiner, and Angeli, of Pozega, Oscar Pongratz, of Agram, and David Fuchs, of Kopreinitz.

Lastly, in the province of Transylvania we meet with a considerable coal deposit in the Zsill valley at Petrilla, Petroszeny, and Zsily. This basin, which stretches nearly thirty miles from north east to south-west, contains seven beds of excellent black Tertiary coal 2 ft. to 24 ft. thick, and is computed to contain 450 million tons. Part of the coal cokes very well, and his fit for the use of blast furnaces. A very good exhibit of this valuable fuel was made by the Royal Administration of Petroszeny. Other coal deposits are known to exist near Hermannstadt, at Michelsberg, Talmes, and Sebes, and near Kronstadt, at Holbach, Illjefalva, and Barot, and at Schässburg, on the Kokel river. At Holbach and Neustadt the coal is probably Liassic, like that of Steyerdorf mentioned above. Exhibitors from this region were the Kronstadt Mining and Smelting Company, and Peter Schnell and Edward Zaminer, of Kronstadt. With these last mineral deposits we finish our review of the coalfields in the Austro-Hungarian Empire; and we propose to look now at the exhibits of the great empire of "All the Russias."

Russia.

Russia, though she commands an enormous wealth of mineral fuel, is economically not yet so far developed that she can greatly profit by it. Her industrial requirements, and her means of communication by the aid of steam, are still on too small a scale to be able to consume very great quantities of coal. Besides this, wood is still almost universally abundant and cheap, and in spite of the wonderful industrial progress which the empire has made since the conclusion of the Crimean war, the time is still distant when its vast mineral resources will be properly utilised. Thus, according to Skaljkowski's "Tableaux Statistiques de l'Industrie des Mines de Russie" in 1871, the total produce of coal and brown coal was only 50,654,562 poods, or somewhat over 850,000 tons. At the Exhibition, however, a very fair impression of the mineral riches of Russia was given by the exhibits of the Mining Committee of the Ministry of Finance of St. Petersburg, which showed a great collection of geological maps and sections, and of statistical and other publications regarding the mining industry of Russia. Another illustration was also afforded by the collection of mineral fuel from the Government of Esthland, St. Petersburg, Nowgorod, and Twer, exhibited by Paul Alexejeff, colonel of the corps of Mining Engineers. The geological exploration of the empire is principally due to G. Von Helmersen, general of the corps of Mining Engineers, under whose intelligent direction the Geological Survey has been going on during nearly thirty years.

There exist four great basins of the coal measures, viz., in Poland, in Southern Russia, in Central Russia, and in the Ural Mountains, and a few smaller ones of younger coal formations, such as Lias and Miocene.

The great coal basin of Poland is the eastern continuation of the vast deposit which we have met in Prussian Silesia, in Moravia, and Galicia; it stretches along the Prussian frontier for about 12 miles, with a width of about 6 miles, and covers over 100 square miles of country. It is estimated to contain about 86 ft. of coal, with more than 4,250 million tons, down to a depth of only 50 fathoms. The principal collieries on the southern part of the basin are those on the Sielce estate, and those belonging to Count Renard; on the northern side are the mines of the Russian Government at Dombrowa, of Von Kramsta, at Gzichow and Zagorz, and of Pringsheim and Co., at Mielowice. The principal ones worked underground, are at Niwka, near Myslowitz, Sielce, and Mielowice; the Max seam at Dombrowa, which is 60 ft. thick, is, however, worked open cast. The Imperial Board of Mine Directors of Western Poland, Jan Zeitler, and Brothers Bauerherz were exhibitors of coal and coke from this district. The produce of this basin is greater than from all the rest of Russia, being over 25 million poods, or about 450,000 tons per annum.

The coal formation of the South of Russia has a very considerable extension in the Government district of Katherinoslaw, and the country of the Donski Cossacks. It stretches from south-west of the Donetz river, along the Sea of Azof, over a belt, 180 miles long and 100 miles broad, covering an area of 20,000 square miles. It rests on the south upon crystalline rocks, is chiefly composed of sandstone and shales, with over a hundred coal seams, and is covered towards the north and west by Permian and Cretacean, and towards the east by Cretacean and Tertiary rocks. Very good geological maps of this district are published by MM. Nossow Frères, by the Councillor of the State of Antigoff and General Von Helmersen. The seams are not very thick, and consist in the eastern part of the coal basin, that is, in the country of the Donski Cossacks, of very pure anthracite; towards the west, near Katharinoslaw, of coal, of which, a small quantity is bituminous, and is suited for making coke. The total output of this basin in 1872 was 20,180,000 poods, or about 360,000 tons of coal and anthracite. This extensive formation has hitherto been but little explored, but it is well known in a few special basins, and its features are described in Von Helmersen's paper, "Des Gisements de "Charbons de Terre en Russie."

The Gmuschefka basin forms an oval 7 miles long by 5 miles wide, and contains four seams, of which the two lower, with 38 in. and 32 in. of coal,

are profitable. The seams are imbedded in sandstone and shale, have a slightly inclined position, and contain first-class anthracite with 86 to 90 per cent. of carbon, and only 1·5 to 4 per cent. of ash. The produce of this basin was in 1872 12,400,000 poods, or about 200,000 tons. The Sadki basin, a few miles north, extends over 16 miles in length and 7 miles in width, and incloses three beds of anthracite, 63 in., 36 in., and 31 in. thick, with 86·5 per cent. of carbon, and 5·6 per cent. of ash. The basin of the river Neswitaja, about 20 miles west from Gruschefka, contains three profitable seams of anthracite, 40 in., 35 in., and 42 in. thick. The fuel is excellent, being composed of 89 to 91 per cent. of carbon, 6 per cent. of gaseous parts, and 3 to 4·79 per cent. of ash. The Novopaulowsk basin stretches between the town of that name, and Romenka, over 45 miles, with 13 profitable seams, which vary from 36 in. to 40 in. in thickness. Although the anthracite is of very good quality, until the present time it has been but little utilized, as is also the case with the two basins just named. Of more importance is the Bulawino basin, in the country of the Donski Cossacks, which in 1872 yielded above 26,200,000 poods, or about 470,000 tons of coal and anthracite. It contains about ten profitable seams, from 28 in. to 42 in. in thickness, and gives employment during the winter months to about 5,000 men, who come from the neighbouring provinces, and return in May when the field work begins. It is clear that under such unfavourable circumstances the mines cannot be profitably worked, as they are almost wholly deserted in summer. The exhibitors from the coal basin of Southern Russia were the Lugan Coal Company, Peter Gubonin, of Katharinoslaw, and Jacob Poliakoff, of Taganrog, who showed at Vienna very good samples of anthracite coal and coke.

The coal formation of Central Russia was only represented by Colonel Alexejeff and the Murajowna Coal Company of Rjaesan. This coal basin covers an area of nearly 80,000 square miles in the provinces of Nowgorod, Twer, Moscow, Kaluga, Tula, and Rjaesan, and it sends off a narrow branch basin towards the north, through the provinces of Nowgorod, Olonetz, and Archangel to the White Sea, this branch, however, only consisting of mountain limestone. The coal measures overlie the Devonian limestone formation in the southern and western parts, and they are partly covered themselves by Permian, Jurassic, Cretacean, and Tertiary rocks. The coal seams rest in some parts, as in the case of Malowka and Tewarkowa, in the province of Tula, immediately upon Devonian limestone, and they are on an average 40 in. to 45 in. thick, though of very variable quality. On the south side of the basin, as at Murajowna, excellent gas coal is raised, but near Moscow the quality seems not to be satisfactory. It is rather curious that this coal, though unquestionably belonging to the old coal measures, has many features in common with the ordinary Miocene brown coal. The annual output is about, 5,000,000 poods, or about 80,000 tons.

The coal formation in the Ural mountains forms on the European slope a narrow band, which begins in the north on the White Sea, and runs parallel with the mountain chain as far as Orenburg, near the Caspian Sea, while on the Asiatic side only isolated patches of it come to the surface. The coal beds occur imbedded in sandstone between the upper and the lower mountain limestone, and have hitherto been very little explored. Some considerable seams, however, are found near Lovniewski 20 feet thick, and Von Helmersen has proved that great mineral treasnres are still hidden here under the Permian rocks. This fuel will become of enormous importance to the development of the Russian iron manufacture, which depends so greatly upon the famous beds of magnetic iron ore in this district, and up to this day the industry is carried on solely with wood charcoal, with the exception of the Alexandrow, Kiselow, and Kamsko-Wotkin forges.

If we now look at the more recent coal formations of Russia, we find Jurassic strata in the south part of the Crimea, but the industrial value seems not yet to be ascertained. Of great importance, however, is the Liassic coal seam of Okrib, near Kutais, in Transcaucasia. It is over 50 ft. thick, and composed of a number of strata, divided by shales, which have partly bituminous, partly anthracitic properties. The new Poti-Tiflis Railway will greatly facilitate this mining enterprise.

Tertiary brown coals and lignite are found in Poland in the valley of the Vistula and its tributaries at many places, as Windariz, Opalowiec, Kolo, Konin, Lodz, &c. At Ekaterinopol, near Kiew, a bed of hard lignite, 10 ft. to 20 ft. thick, is known over a great surface; another, composed almost entirely of trees, branches, and leaves 8 ft. to 10 ft. thick is found in the Oka valley in Central Russia, and similar deposits are in the province of Ukraine, and near Brody, in Galicia. Siberia, also, is not devoid of Tertiary mineral fuel. Brown coal exists near Irkutsk and Kamenk, on the Isel river, likewise in the Tundru district, in North Siberia, with sandstone along the rivers Lena, Gorbita, and Mura. In the Orenberg steppe, 70 miles east from Orenburg, a lignite bed, 9 ft. thick, and containing over four million tons, has been explored at the Jar-Kue wells. Brown coals have also been discovered in the Kirgise steppe, on the Mangyschlack peninsula, on the east of the Caspian Sea, in Kamschatka and the island of Sachalin, on the Pacific, where a seam of excellent black glance coal 4 ft. thick, is worked for the use of Russian steamers in Eastern Asia.

This short review will show that Russia, though she is not yet so far advanced as to feel the necessity for large quantities of coal, will be able to supply herself so soon as the want is felt. She owns already over 14,000 versts, or 10,000 miles of railways, and a numerous fleet of river steamers, of which number over 500 ply upon the Volga river and its tributaries alone; and although most of them are still worked with wood fuel, the time must be near when coal will supersede it entirely.

Roumania.

The exhibits of Roumania, a country which borders both on Russia and Austrian Hungary, comprised about a dozen samples of mineral coal from that country. None of them, however, were derived from the actual coal measures, and they seemed all to belong to the tertiary formation. No mines of any value as yet exist in that half-civilised country, and as in Russia, it will take a long time before the subterranean fuel deposits of these regions can be made available. The most important of them is the southern continuation of the Transylvanian coalfield of the Zsil Valley already mentioned. This tertiary coal basin stretches across the Vulcan Pass into Roumania, following the valley of the Wallachian Zsil, near Lupny, Matsesd, Urikany, and Valyroschia, where the coal bed contains a bank of black band 15 in. thick, and rests upon a seam of 24 in. of clay ironstone. At Plojesti black glance coal is found, as well as at Komanest, near Backan, and ordinary brown coal and lignite exist in numerous localities on the south and east of the Carpathian Mountains, and at Czerneez and Malowica, in the valley of the Danube. Passing along the south of that river the principality of Servia is reached, and here near the Sememendria on the Danube, and in the valley of Resava, an extensive tertiary coal basin, covering an area of 1,400 square miles is met with. At the Dobra mines about 50,000 tons of good brown coal are raised annually for the use of the steamboats which run on the Danube.

Turkey.

The empire of Turkey, which comes next under review is, as may be expected, still very backward in its mining industries; however, some samples of mineral fuel were exhibited at Vienna. The country has hitherto been very imperfectly explored by geologists, owing to its semi-barbarous state, and there seems little chance for improvement under existing circumstances. It appears that at present only one basin of the coal measures is known to exist in Turkey, that is on the northern slope of the mountains, of the Czipka Balkan, which separates the province of Roumeli from Bulgaria. Resting upon mountain limestone and covered by red, probably Permian sandstone, the coal formation here comes to the surface south of Grabowa, stretching some 50 to 70 miles east and west. Near Radiewce its sandstone and shale contain three coal seams with 25 ft. of coal at Bonef Kubak, and Dissakderessy, also at Peitschowa, near Grabowa. The discovery is rather new, and it is only lately that a German company has begun to work these coalfields.

Besides the formation of Grabowa, several tertiary basins containing very good glance coal and lignite were represented by samples, although very few are yet worked. Beginning with the vilajet Bosnia, which borders Austrian Croatia, there is an extensive tertiary basin continuing from Austria over the Unna river, and along the Sanna river from Kostainica and Novi to Priedor, Kosaracz, and Banjaluka. Near Priedor it contains beds of excellent glance coal, which are quite within the reach of the Ottoman Railway, between Kostainica and Banjaluka. Nevertheless, the locomotives of that line only burn Austrian tertiary coal, which is carried a very long distance—from Sagor, in Carniola—and is very expensive.

In the province of Bosnia, pitch coal is also found at Guczjagosa, near Travnik, and brown lignite at Konjitza, south of Sarajevo. The province of Albania likewise possessed tertiary coal, near Janina and Volas, and in the vilajet Pisren or Macedonia, samples were exhibited from Nish and Leskowaz, while at Czirkova, Buczina and Radomir, west of Sofia, a seam of excellent brown coal, 6 ft. to 9 ft. thick, has been discovered. Deposits of such fuel are also known to exist at Domous Dove on the Bosphorus, and south of Salonica, in Thracia. Half a dozen samples were exhibited from Asia Minor, particularly from Smyrna, in the vilajet of Aidin, and from the neighbourhood of Brussa, in the vilajet of Chodawendkjar. The best known and worked coal basin is, however, that of Eregli or Heraklea, on the shore of the Black Sea, which extends over 90 miles, and produces 200,000 tons annually for the use of the Turkish steamboats on the Black Sea.

Greece.

Greece does not own much mineral fuel; a couple of samples of brown coal however were exhibited by Theophanes Rentis, of Corinth, and by the Greek Metallurgical Company of Attica. The latter works a bed of pitch coal 9 ft. to 12 ft. thick at Orapo, in Eastern Attica. Of more importance is the deposit of Castrocavallo, near Kumi, on the east coast of the island Eubœa or Negroponte. Two seams of brown coal with lignite, containing traces of dicotyledons and impressions of frogs, are found here 6 ft. to 9 ft. thick covered by beds of clay and marl.

Africa.

We have now finished our review of the European exhibits of mineral fuel, and may proceed hastily to survey those of the other continents, beginning with Africa. From Oued Zavnia, in Algeria, a sample of lignite was sent, and it may be mentioned that in Northern Africa similar coals are found in the same province at Doueira and Beled Boufrour; at Hadjar Roum, in Oran; at Ymendan, near Constantine, and likewise near Karahissas and Tripoli, in the Turkish vilajet of Tripolis. From Southern Africa coal samples were exhibited by N. Alder, of Port Elizabeth, in Cape Colony; these coals seem to be of tertiary origin, like the seams near Capetown and Table Mountain, of which specimens were contributed to the Paris Exhibition in 1867.

India.

The Vienna Exhibition contained a very excellent collection of coals in the Indian department arranged by Professor T. Oldham, the celebrated superintendent of the Geological Survey of India. This institution also exhibited its geological maps of parts of India, and the "Memoirs of the "Geological Survey of India," which gave a lucid explanation of Indian geology, so far as the explorations have been completed. Nearly all the coal formations of India lie in a belt between 20 deg. and 25 deg. parallels of latitude, bounded by the Ganges on the north, extending beyond the Godaverey on the south, and from east to west stretching from the neighbourhood of Calcutta to some distance down the valley of the Nerbudda. Nearly all the coal basins of India belong to one geological formation, which corresponds to the carboniferous formation of Australia, and differs very little from the coal measures of Europe. It is called the Damuda formation, from the name of the river Damuda in Bengal, where it is fully developed; it is

composed of two stories or groups, the upper one 5,000 ft., and the lower 2,000 ft. thick, each containing several seams of coal. The coals of India are generally somewhat different from those of this country, in consequence of their excessive lamination. Most of them contain from 10 to 30 per cent. of ash, and the proportion of fixed carbon seldom exceeds 60 per cent., being only 52 on an average; while average English coal has only 9 to 7 per cent. of ash, and 68 of fixed carbon. Consequently Indian coal can only do from one-third to two-thirds the work performed by the same amount of English coal. It is, therefore, ill-suited for use in sea-going steamers, and the development of the coal producing industry of India will be principally caused by the local demand for public works, railways, river steamers, and manufacturers. Some seams will even give a very fair coke, fit for the manufacture of pig iron, and the quality of such carbonised fuel will be greatly enhanced as soon as coal-washing machinery is employed in India as an auxiliary to the coking process.

The coalfields of India are classed in four groups. First come those of the Rajmahal Hills, and the Damuda Valley, containing coal beds 3 ft. to 12 ft. thick; the transport from here is, however, difficult, and the coals yield only 45 per cent. of carbon on an average, with 14 to 15 per cent. of ashes. By far the most important is the Raneegunj district in Bengal, and the return for 1868 shows that in that year there came from this source 493,000 tons of the whole 497,000 tons extracted throughout India. This coalfield commences about 120 miles north-west of Calcutta, forming a basin 40 miles long and 18 miles broad. The coal measures bear east and west and dip slightly southward, being 8,000 ft. thick with 100 ft. to 120 ft. of workable coal, which, however, is only partly bituminous, and yields 50 per cent. of carbon, while it contains from 12 to 15 per cent. of ashes. This coal basin is estimated by Dr. Oldham to contain 14,000 million tons, and is intersected by two branches of the East India Railway. In 1872 there were 44 mines at work upon seams varying from 4 ft. to 35 ft., and their output has doubled in the last 12 years. The Raneegunj coalfield covers an area of more than 700 square miles, and over a great part of it workable seams of coal of considerable thickness occur within 1,000 ft. from the surface; but there is a gradual diminution in thickness of the coal-bearing strata to the westward. Samples from this district were exhibited by the Raneegunj Colliery, the Nimcha Colliery, the Mudhoopoor Company, and others, which contained 66·5 to 67 per cent. of carbon, from 4·79 to 4·89 per cent. of hydrogen, and 13 to 17 per cent. of ash. Very fair samples of coke were shown by the Sanktoria Colliery, with 74·6 per cent. of carbon, the Bengal Coal Company, and others. The Kurhurbard coal district, in the valley of the Baraker, a tributary of the Damuda, covers an area of 18 square miles, containing seams of good coal 8 ft. to 14 ft. thick, the best being that of Lodona with 63 to 68 per cent. of carbon and 12 of ash. Next to the Lodona coalfield come, towards the west, those of Therria, Bokaro, Ramghur, Hoharo, Palamow, &c., with less coal and of inferior quality. The contents of this basin are estimated at 200 million tons. The second group of coalfields consists of a number of basins, scattered thinly over an immense tract of the wildest country in India, and none have been thoroughly explored; such are the basins of Rewah, Sirgujah, Chota, Nagpoor, Talcher, and others.

The third group is included in the Nerbudda Valley and the Saptura Hills. It is believed that a large quantity of coal exists there, and that the quality of much of it is little inferior to that of the Raneegunj. The Garrawarra Colliery works a seam 22 ft. thick; and the Nerbudda Coal and Iron Company exhibited specimens of coal from this district. The forth group comprises the new coalfields in the valleys of the rivers Wardha and Godaverey, where coal is known to exist in several localities, and though inferior in quality to that of Bengal, is still good encugh for railway purposes. It is computed that the Warora beds in the Chandah district contain 5,000,000 tons available. The most southern point at which coal has as yet been discovered in India, is Sinharani, 30 miles south-east of Kamaram. Besides these four groups of coalfields there are two to the eastward of Calcutta. One at the Khasi Hills, where some coal of excellent quality has been found 4,000 ft. above the level of the plain; the other in the extreme end of the Assam

Valley; here are several seams of excellent coal with only 2 to 5 per cent. of ash, but the country is densely covered with forest and very thinly populated, which makes it unfavourable to commercial enterprise. India owns also some not unimportant deposits of tertiary coal and lignites. Such is the case at Sewalik on the Kalawoda pass of the Himalayan Mountains, where trees are found within brown coal; again in the Travancore Mountains; in the Cassyah Hills, in Scinde; in the Nummulite formation of Upper Assam, at Jaipoor, where a bed 17 ft. thick is covered by sandstone; in Ava, on the Irrawaddy River, and on other places. Up to the present day they have been, however, of very little economical importance.

East Indies.

From the East Indian Archipelago no specimens of mineral fuel were exhibited, although coal mines are worked by an English company upon the island of Labuan on the north-east coast of Borneo. Four seams of tertiary coal, 3 ft. to 11 ft. thick, are worked underground, and produce very fair coal with 64·5 per cent. of carbon and 7 to 8 per cent. of ashes, for the use of steamboats. Neither were the Dutch islands represented, although coal beds are known to exist in many parts of Sumatra, Java, and Borneo. Professor Hochstetter, who has visited these regions, distinguishes three series of coal-bearing strata. The lower group contains many silicified trees, but hardly any marine shells; the middle consists of thick beds of limestone and marl, containing Nummulites in Borneo, and corals in Java; the upper group is composed of shale and sandstone, and encloses a rich fauna of marine mollusks plants, and the amber like mineral, retinite. The principal coal mines of Borneo are in the south near Banjermasin, in the west on the Kapuas river, and also near Sarawak. In Java numerous beds of brown coal and lignite have been explored by Dr. Junghuhn, and in Sumatra, coals are found near Bencoolen, Meteh, and Palembang.

China.

In the collection of products from Siam, samples of coal were also missing; but a very complete series of anthracite and bituminous coals, coke, and lignite, was included in the exhibition of the Chinese Government. The coal resources of China have been, until recently, comparatively unknown. From the reports of missionaries it was understood, that the mountains of the province of Shantung contained coal beds, as also does the valley of the Lan-fei-ho and the plain, near Yi-chow, in longitude 118 deg. 24 min. east, and latitude 25 deg. 15 min. north, where the coal yields an excellent kind of coke, used by the Chinese for smelting purposes. More accurate and reliable information, however, has been furnished by Baron von Richthofen, an accomplished geologist and geographer, who has travelled for some years in all directions through the Chinese Empire. From these researches we learn that China is almost exclusively made up of the most ancient formations, belonging to the Silurian, Devonian, Carboniferous, and Permian ages, and that none of them is more universally distributed over the country than the Carboniferous, which contains coal beds wherever it occurs, and that coal-bearing strata are also found of Permian and Triassic age, as in European countries. The great Chinese coal measures are composed, in the main, of soft rocks, and have undergone a vast destruction by denudation, far more apparent in the maritime provinces than further inland in the provinces of Shansi, Hunan, Yunan, and Kansu. Here the amount of denudation has just been sufficient to lay bare the coal-bearing strata under the most favourable circumstances, and to render accessible marvellous treasures of coal, which are not outrivalled by those of any other region of the globe. In the province of Sechuen, the coalfield covers an area of about 100,000 square miles, as is demonstrated by outcroppings which occur along the whole line of the periphery. China indeed would appear to rival the United States with regard to coals, and it may prove the richest of all countries in this respect. Attention is deservedly directed to the province of Shansi, which contains at least 30,000 square miles of coalfields, the greater portion of which has bituminous coal of superior quality, as is

demonstrated by the specimens exhibited, this coal being largely used for iron smelting and other metallurgical operations. The rest contains veins of first-rate anthracite, attaining a thickness of 30 ft., from which the mineral is simply quarried and sold for 7*d.* a ton at the pit's mouth. The influence which these treasures may be destined to have on the future development of Central Asia and Siberia, when they will be connected with the civilised world by railways, leading through the province of Kansu, the oasis of Hami, and the region of Flo, on the borders of Russia, is not easy to conceive.

Japan.

Japan was not behind in showing numerous samples of coal in her exhibition, these samples being partly derived from the neighbourhood of Nagaski and Simabara. They were mostly tertiary pitch and glance coal, as, for instance, those from Kinsin and Nippon and the island of Ama-Ksa. The real coal measures, however, seem also to exist in Japan, as at Gorio and Hirado excellent coals are found, which contain 72 and 73 per cent. of carbon. Upon the island of Jesso, also at Kaianoma, four seams of bituminous coal, 1, 3, and 4 to 6 ft. thick are found, this coal yielding 30 to 40 per cent. of gas and leaving 10 to 12 per cent. of ash.

Australia.

We turn next to Australia, and find that the oldest of our colonies there, New South Wales, was, for some unknown reason, entirely unrepresented at Vienna, while Queensland, Victoria, and New Zealand showed a large number of exhibits. This is the more to be regretted, as New South Wales is destined to become one of the largest coal-producing countries of the globe. In 1870 this colony raised over 1,000,000 tons of excellent coal from about 34 mines, principally in the districts of Newcastle and the Hunter River, about 100 miles north from Sydney, and 511,000 tons were exported from the harbour of Newcastle alone, worth 700,000*l.* It appears that the coal formation of Australia extends parallel with the eastern coast, along the Blue Mountains, over a very large district from the colony of Victoria, through New South Wales and far into Queensland, containing many beds of excellent bituminous coal, which makes very good coke, and yields over 80 per cent. of carbon, with only to 2 to 4 per cent. of ash. In fact, this coal is by far the best in all Asia and the Pacific, and it is very profitably exported to the harbours of China and California. It is also used for iron making, and quite recently some large iron works at Lambton, near Newcastle, were started; the ore being brought from Queensland, New South Wales, and South Australia. Though the coal measures have an enormous development they are at present only opened in a few districts. The mines are in the coalfield of Newcastle, and also near Raymond Terrace, Singleton, and other localities. Next follows the Wollongong basin, 40 miles south of Sydney, with the important Wollongong and Bellambi mines. This basin extends over 30 miles south from Wollongong, and west far into the Berrima district, where four collieries are worked. West of Sydney are the Hartley and Mount York coalfields, the latter containing excellent cannel coal, which is used for making gas at Sydney and Melbourne, and for the manufacture of petroleum and kerosene. The coal measures contain 11 seams, from 3 ft. to 30 ft. thick, near Newcastle, but they far from being properly explored. This is still less the case in Queensland, where the coal formation is known to exist north of the Condamine river, and in the valleys of the rivers Mackenzie and Robinson. In Moreton Bay the coal crops out, and seams may be traced all along the Brisbane and Bremer rivers. The age of this carboniferous formation is, however, not yet ascertained with certainty, but by some geologists it is taken for Mesozoic or Liassic. Exhibits of coal were made at Vienna from the Tivoli coal mine near Ipswich, where at 350 yards' depth a seam of soft coal, 4½ ft. thick, is worked, while a very good coke is made from it in 23 kilns. The Allora Coal Company, Darling Downs, 152 miles from Brisbane, work a seam 28 in. to 30 in. thick; the Bingera coal mine, near Bundaberg, Lower Burnett, and the Rosewood mine, West Moreton, work three seams about 18 in. each. The Aberdare coal mine, 5 miles from Ipswich, has a seam of 4 ft., and the Flagstone Creek

coal mine, Toowoomba, one of 18 in., and at Blackfellows Creek, near Gatton, a seam of cannel coal, 7 ft. to 10 ft. thick, is known. The coal of Queensland is generally very pure, but the extent of the coal beds is only very imperfectly explored.

From the colony of Victoria samples of coal were shown by the Mining Department of Melbourne, probably from the northern provinces, while beds of hard brown lignite are found in the neighbourhood of Ballarat.

New Zealand.

New Zealand exhibited a variety of coals, none of which, however, come from the real coal measures. The formation to which they belong are the Cretaceous and Eocene. In the province of Nelso, near Cape Farewell, the former is predominant, and the Collingwood Company works there six seams, 1 ft. to 4 ft. thick, of very good bituminous gas coal; the Ajax Company one of 10 ft.; the Ngakawau Company, at Mount Rochfort, a bed of 16 ft.; and the Brunner Mine one of 18 ft. thickness. This Cretacean coal is black, gives a hard metallic coke, and evaporates 7½ lb. of water per one pound of fuel, that is to say, almost as much as the English Hartley and Wallsend coals will do. The coal of Pakawau is less bituminous. Tertiary brown coals are found in the same province on the Upper Buller river and at West Wanganui; they are pitch coals, and their evaporating power is 4·2 lb. The province of Canterbury owns tertiary anthracite glance coal at the Acheron river and the Malvern Hills, and at Hill's Drive, near Selwyn, and Preservation Inlet. In Auckland, the Waikato Coal Company work a bed of pitch coal 18 ft. thick, and semi-bituminous coal occurs there at Kawa Kawa, Wangarei, and Wangaroa. Ordinary brown coal is found in Otago at Kaitangata and Saddle Hill, and a seam of 8 ft. pitch coal at Shag Point. The exhibitors were the Colonial Museum, the Provincial Government of Nelson, the Collingwood, Oakden, Ajax, Ngakawau, and Waikato Coal Companies, and Messrs. Hart and Rowley.

America.

Looking now at America, the last continent in our review of mineral fuel, we find the Pacific coast very deficient in coals. The extensive coal formation of Vancouver Island is of tertiary age, and stretching from Georgia Bay as far as the Island of Saturra, contains two seams of ordinary brown coal and pitch coal of very good quality, 6 to 8 ft. thick; the coal is worked at several places for steam purposes with considerable advantage. In Washington territory, opposite Vancouver Island, an extensive tertiary basin is found near Bellingham Bay. It is composed of sandstone, and contains 10 seams of bituminous glance coal, with an aggregate thickness of 116 ft. The coal gives a very good coke and is fit for the use of blast-furnaces. Tertiary coals are also found in California at Santa Clara and Goose Bay, where three seams, one 9 ft. thick, cover a great surface, and contain a good glance coal with only 3 to 4 per cent. of ash; similar coal beds are found 23 miles south of Cape Flattery, and beds of lignite at Port Oxford and Astoria. Coals of Cretacean age have also been discovered in the Sierra Nevada. In San Salvador, in Central America, a large seam of pitch coal is known to exist near the meeting of the rivers Titigupa and Lempa, and on the Isthmus of Panama, near Cultivation Creek and Blando river, an Eocene formation contains six seams of excellent black bituminous glance coal, 30 ft. thick. On the west coast of South America mineral fuel is only known in Chili at Lota, near Valparaiso. Here a bed of black pitch coal is found, as is the case near Concepcion and Calcurra Bay, south of Valparaiso. The coals yield here over 70 per cent. of carbon, with 5 to 7 per cent. of ashes. Besides these tertiary coals others of Liassic age seem to exist at St. Jago and Aconcagua, in Chili.

In Brazil several coal basins are known, though none of them have as yet reached great importance. In the province of Rio Grande do Sul, west of Porto Allegre, three coalfields are explored. The greatest is that of Candiota covering an area of 150 square miles. In the mines of the Rio Grande Coal Company several seams, with 65 ft. of good bituminous coal (which, according to the researches of Professor Agassiz, belong to the real Carboniferous

period), are worked with great advantage, the thickest seam being 25 ft. A second basin is that of Rio Ratos, with 50 square miles; the coal specimens shown from it by Dr. Ubatuba much resemble English Newcastle coal, as do the coals of the third basin of Rio Tubarao or Passa-Dous, in Santa Catharina exhibited by Viscount Barbacena. All these basins promise to become of the utmost value for the development of Brazilian industry. The United States of Venezuela likewise made a good show at Vienna with their specimens of coal, which are almost all derived froom the Eocene formation at Curamichate near Coro, west of Caraccas, and at Piaco and Barcelona. The coal is glance coal, and part of it is suited for coke; other beds are composed of lignite. The formation also contains anthracite coal, near La Guayra, samples of which were exhibited by Mr. Stelling. Lastly, in Columbia an extensive Eocene coal formation exists at Chirigui, in the province of Veragua. Here six beds of coal, 73 ft. thick, and containing black glance coal with six per cent. of ashes, extend over a belt 50 miles long, and 5 to 14 miles broad, between the Rio Changuinola and cape Valienti. The best coal is found at the mouth of the Changuinola, where it is bituminous, while on other places it becomes anthracitic or lignitic.

We conclude our sketch of the mineral fuel exhibits at Vienna with the United States of America. As is well known, North America is one of the richest coal countries in the world. Her coalfields, west of the Alleghany Mountains, extend over the greater part of Pennsylvania, Ohio, Maryland, West Virginia, Kentucky, Tennessee, Alabama, and Georgia, covering an area of more than 55,000 square miles of bituminous coal. The development of the North American coal industry has made rapid strides, and the annual production of coal has increased from 21,000,000 tons in 1866 to 34,000,000 tons in 1871, and to 41,752,000 tons in 1872. The quality of the coal is very good, and about one half of the output consists of anthracite, and the other half of bituminous coal, which makes excellent coke. The latter is principally raised in Pennsylvania and Ohio, where the great bituminous coal bed stretches from Pittsburg as far as west of the Ohio, its northern outcrop being 5 miles of Pittsburg, its southern near Beaver. It is composed of three layers, the main breast coal, 5 ft. to 6 ft. thick, a stratum of shale, and again of coal. The anthracite region, however, composes the eastern portion of the great carboniferous formation, and in Pennsylvania alone it covers 297,000 acres, containing in the countries of Schuylkill, 108 ft., Lehigh, 50 ft., Shamokin, 70 ft. Lackawanna, 60 ft., and Wyoming, 100 ft. of anthracite coal. The most important is the Schuylkill district, where the Mammoth Seam contains from 20 ft. to 60 ft. of coal. The quality is generally very good, Pennsylvania anthracite containing 85 to 90 per cent. of carbon and 1 to 5 per cent. of ashes; Pennsylvania and Maryland steam coal 71 to 77 of carbon and 6 to 9 of ash; and bituminous coal 62 to 65 of carbon, 26 to 35 of gaseous substances and 2 to 9 per cent. of ash. The best steam coal comes from Cumberland, in Maryland. Exhibits of American coals and coke were shown at Vienna from Pennsylvania by Amasa McCoy and Philo Norton, and by the Dunbar Iron Company; from Ohio by the Cincinnati, Rockport, and South Western Railway; and from Alabama, by R. Rothwell. Coals from Indiana were exhibited by the state geologist, Mr. E. D. Cox, of Indianopolis, and by the Otter Creek Black Coal Company, these coals being anthracitic, but used in blast and puddling furnaces. Professor Guido Kustel showed black coal, most likely of more recent age, from Weber river in Utah. The United States own also enormous masses of tertiary coals, a broad belt of such deposits, stretching east of the Rocky Mountains, from north to south, through the States of Montana, Dakota, Wyoming, Nebraska, Colorado, Kansas, Indiana, and Texas, as far as the Gulf of Mexico. The mineral treasures which are heaped up here are as yet very imperfectly known, and it will be reserved for future times to make the best use of them.

METALLURGICAL EXHIBITS.

In the present section we propose to pass in review the metallurgical exhibits represented at the late Vienna Exhibition, omitting, however, any notice of wrought iron and steel, which will be treated in another and independent division. Within the compass of our review will consequently fall the exhibits of the ores and metallic productions of, and of the smelting arrangements for, copper, lead, silver, gold, platinum, zinc, tin, nickel, cobalt, mercury, and antimony. In the first place we shall speak of those metallurgical exhibits which had reference to copper.

Copper.

In the British department we only found a few specimens of copper ore and lead ore, exhibited by Newton, Keates, and Co., of Liverpool, which had no value, and demonstrated nothing, though they were intended to illustrate the ore trade. It was only in the British Colonies that we found anything worth speaking of. New Zealand, which in every respect was worthily represented, brought forward some productions of her copper mines at Hope Creek, Thames district, province of Auckland, these consisting of specimens of copper pyrites, and blue and green silicate of copper or Beaumontite, which was also the principal mineral of the once famous Burra Burra mine in South Australia. There was also rich copper pyrites with 11 to 35 per cent. of copper from a lode in mica schist, 3 ft. to 5 ft. wide, at Moke Creek, Wakatipu Lake, and from the Decimal Company's mine, Collingwood, Nelson. Some grey sulphide copper ore, containing a little silver and gold, and 65 per cent. of copper, was exhibited from Wangapeka, province of Nelson.

From the Peak Downs mine in Queensland, W. Mort and Co. exhibited some splendid samples of malachite or carbonate of copper, which rivalled the best specimens from Siberia, or from Loanda, in the Portuguese settlements in Western Africa. The once celebrated copper mines of Burra Burra and Kapunda seem, since the discovery of the goldfields in Victoria, to have been very much neglected, though they are not exhausted. The former, worked by the English and Australian Copper Company from 1846 until 1857, produced alone about 128,600 tons of copper ore, with an average yield of 20 per cent., worth three million pounds in the port of Adelaide, while the Kapunda mine gave 24,000 tons of 19·5 per cent. during the same time. Unfortunately the miners—over 1,000 at Burra Burra, and nearly 300 at Kapunda—were tempted to go to the gold diggings, and to leave the mines and smelting works to take care of themselves. During the last 12 years the Australian copper trade has only gradually recovered, and the copper produced at Burra, Wallaroo, Kapunda, and Currawang, both cake and ingot, again commands very good prices in the European markets.

In the very interesting mineral exhibition of India we found copper ore and copper shown by the Central Provincial Committee and by the Local Committee of Amritsir. The metal, made from the yellow sulphide of copper, appeared of excellent quality, and its manufacture was very well represented by samples of smelting products, and a very interesting model of an Indian copper-smelting works, made to scale. From this we gathered that the Indian copper-smelting process is as follows: The copper ore is very finely pulverised, mixed intimately with cowdung, and made into balls of the size of a fist. These are well dried and piled upon brushwood in a heap, which is then lit, when the whole mass ignites and slowly smoulders away, until all the organic matter and the greater part of the sulphur is burnt off, the calcined ore, consisting of oxide of copper and iron, being left behind. This calcined ore is then smelted with a suitable flux and wood charcoal in a low kind of cupola, about 5 ft. high and 1½ ft. wide, which on each of three sides has a tuyere made of burnt clay, for the admission of air from three pairs of hand-bellows, while

the front side of the furnace contains the tapping hole. After the smelting process has gone on for some hours, the liquid contents of the furnace are tapped off into a flat hollow, where the metal settles at the bottom, the regulus or undecomposed sulphide of iron and copper in the middle, and the slag on the top. The raw or blister copper, got in this way, still wants refining, which operation is performed by remelting it with charcoal under the oxidising action of the blast from hand-bellows in a small hearth or hollow. By this treatment the last traces of sulphur and iron are removed, and the metal becomes tough and malleable, Seeing the very good quality of the copper, it must be admitted that the native smelters have attained a high degree of efficiency in their craft, though their method seems to be still about the same as was in use more than 3,000 years ago.

France did not exhibit any copper ores or metallurgical products of copper smelting. We found, however, a very complete collection of copper, brass, and bronze articles, shown by J. J. Laveissière and Sons, of Paris and Rouen. Amongst them were some very fine and heavy copper plates, weighing 2,267 kilogrammes (4,988 lbs.) each, and showing a very fine-grained and regular fracture; also copper sheets, 3 metres (9 ft. 10⅛ in.) wide, for the sheathing of ships' bottoms, and copper pipes from 11 to 440 millimetres (0·43 in. to 17·32 in.) diameter, drawn out without soldering, and of excellent quality. There were besides wires, fire-box plates for locomotives, and hammered copper bottoms for stills of 3·2 metres (10 ft. 6 in.) in diameter. Amongst the articles made of brass there were similar plates, sheets, and tubes; and of bronze articles we noticed alloys for coin and cannon in various stages of manufacture. There was, in particular, the new French "canon de sept" breechloader, which deserved attention, and figured as a centre-piece in Messrs. Laveissière's trophy in the Rotunda. The firm has succeeded, at least for small ordnance, in producing a very homogeneous alloy of bronze, as is shown by the analyses exhibited. The average of five determinations of samples taken from the muzzle, the trunnions, and the breech, gave the following composition:—

	Copper.	Tin.	Zinc.
From the bore -	90·876 -	9·108 -	0·020
From the outside -	90·730 -	9·250 -	0·020

These two analyses are almost identical, while in ordinary bronze ordnance the alloy of the interior usually holds more tin than that of the periphery. From the province of Algiers we found copper ore from the mines of Oued-Abeidja, yellow sulphide from those of Mouzaïa, and copper pyrites from Zaccarkharvi, Oued-el-Kebir, Hallelah, and Aguil.

From the Iberian Peninsula Portugal made a show of copper ore, principally pyrites from Alvito, by the Compania Mineracao Transtajana, the Lusitanian Mining Company, and the Viscount of San Domingos. Spain exhibited ore from Bailen by the Sociedad Los Amigos de Redin, from Guejar, near Granada; carbonate of copper from the Britannia mine, near Xerez, and Yinana, near Almeria, and copper-uranite from Mine Maria Josefa. Copper pyrites was also exhibited from the Ines, Incarnacion, and Virgen mines, near Guejar, in Granada, and from Molina, near Guadalajara, the latter sample being argentiferous. Of great importance were the samples of coppery iron pyrites from Andalusia, from whence large masses of mineral are annually exported for use in the manufacture of sulphuric acid in this country. In the province of Huelva, south of the Sierra Morena, extends a great district, composed of lower carboniferous rocks, which contains five zones of mineral deposits in connexion with dioritic porphyry. At Rio Tinto these lodes, containing copper, sulphur, and formerly lead, have been worked ever since the time of the Carthaginians, by the Romans, the Moors, and the Christians. The average yield of the ore is about 4 per cent. of copper, sometimes rising, however, to 12 and even 20 per cent. The ore beds are of a lenticular shape, and vary from 5 to 20 metres in thickness. The principal mines of the district are those of Rio Tinto, Tharsis, Buitron, Santo Domingo, La Zarra, Lagunazo, La Concepcion, San Telmo, San Miguel, Penna de Hierro, Pyratos, Pradovicjosa, and Carpio. The annual production of the district is about 400,000 tons of ore, containing 10,000 tons of copper, which is all shipped

in the port of Huelva for our chemical works. After the calcination of the ore for the benefit of its sulphur, the copper is here extracted by a wet chloride process, and the residue, almost pure red oxide of iron, is sold to the puddling works as a fettling, and to the blast furnaces as a rich iron ore. Very good specimens of the Huelva copper ore were exhibited from Rio Tinto, Valverde, and by the Tharsis Copper Company. Cake copper and copper slabs were exhibited by Gerezy Pinana, of Granada; Artaloitia and Brothers Daguerre, of Seville, the Direccion General de Propiedades and Manuel Campillo, of Teruel. The Spanish copper-smelting process is generally carried out in small blast furnaces with charcoal, only the last operation of refining and toughening is sometimes done, after the English fashion, in a reverberatory furnace.

Turning to Italy we found the Government mines and works of Agordo, near Belluno, in Lombardy, represented by a very complete collection. It showed that the copper ore, which occurs there, embedded in clay slate in the shape of a large bunch or pocket intimately mixed with iron pyrites, is broken into big lumps and calcined in large heaps, when the sulphur partly burns away, and the greater part of the sulphide of copper concentrates in small nuts or kernels within a crust of oxidised ore. The kernels are carefully collected and smelted for copper; the sulphate of copper, which forms in the crust of the oxides, is washed out, and the copper precipitated by iron, while the red oxide of iron, which is left, is worked into "caput mortuum," or polishing powder and red paint. Some sulphur is also collected during the first calcining operation. The ores and metallurgical products from Vallalta, Vallimpenna, and Agordo, were exhibited by the Italian Government, and by Chevalier Manzoni. Samples of copper ore and copper were also shown from the works of Vallpelina, Bard, and Ollomont, near Aosta, in Lombardy, by Cornelissen, Simonis, and Co., and copper ore from the Sesti Levanti mines, near Genoa, and from Lanusei, near Cagliari, in Sardinia. For the productions of the copper works at Monte Catini and Massa, in Tuscany, we looked in vain.

Turning next northward to Sweden, we found a good collection shown by the Stora Kopparberg Company of Fahlun. These mines have been worked for nearly six centuries upon a bunch of ores at least 1,115 ft. high, 787 ft. wide, and 525 ft. thick, which is embedded in mica, schist, and quartz, and consists of an intimate mixture of iron pyrites with sulphides of copper, lead, and zinc. The ore of the principal mine, Storgrufva, yields, on an average, only 2·5 to 3 per cent. of copper; however, rich ore of 34 per cent. is also found, and the galena contains some silver and gold.

The annual produce is about 750 tons of copper, and 115 tons of blue vitriol or sulphate of copper, besides some sulphur and red paint. The smelting operations are carried on in blast furnaces with charcoal; only the refining of the blister copper is done in a reverberatory gas furnace with Siemens' heat regenerators and Lundin's gas generator, with water-jet condenser, the fuel being exclusively sawdust and saw-mill refuse.

Norway owns 11 copper works, which produce 520 tons of copper annually, with about 255 men, the largest being those of Röraas, near Drontheim, where copper mining has gone on since 1644, at the Storvarz, Mug, and Kongens mines, and of Alten, near Hammerfest, in Finmarken. The Alten Copper Company has worked since 1839 upon several copper lodes, which traverse the Silurian limestone, the ore is copper pyrites, and partly blue copper, which are smelted with English coal, and after the English method, in reverberatory furnaces. The company exhibited a selection of ores, copper regulus, and refined copper. Coppery iron pyrites with 2 to 4 per cent. of copper was shown from the Ytteröen Mining Company's mines on the Isle of Ytteröen, near Drontheim, and from the mines of the Vigsnaes Copper Company upon the Island of Karmöen, near Haugsund, on the west coast of Norway. The company exhibited also a single block of ore, weighing five tons, and samples of washed ores, and plans and photographs of the works. The produce of these mines in 1872, was 34,600 tons of lump ore, and 6,600 tons of washed ore, which were almost exclusively shipped to Newcastle and Hull. The average yield of the ore is 4 per cent.; a small quantity, however,

is found to contain upwards of 12 per cent, Belgium did not show any copper, but the exhibits of phosphor-bronze by Messrs. Künzel and Levi were rather remarkable. At Val Bênoit, near Liége, the firm manufactures this material, containing only $\frac{1}{4}$ to $\frac{1}{3}$ per cent. of phosphorus, on a large scale. It is remarkable for its great strength and tenacity, if compared with either ordinary bronze or copper, and numerous articles made from it, principally cannons and firearms, were exhibited. It is doubtful whether its superior strength is due to the small proportion of phosphorus which it contains, or whether it does not arise from an improvement in the quality of the copper effected by the presence of the phosphorus and the total absence of protoxide.

We have next to speak of the specimens from Germany, which included a variety of copper exhibits. On the northern slope of the Harz Mountains we find, near the old imperial residence of Goslar, the great metallic deposit of the Rammelsberg, from which copper and lead have been extracted for more than 900 years, they having been discovered in the reign of the Emperor Otho I., between the years 930 and 940. The geological formation consists of the lower carboniferous strata, as at Agordo and Rio Tinto, and contains a lenticular bed, or bunch of ore, 1,960 ft. long and 262 ft. thick on the outcrop, while lower down its thickness does not exceed 46 ft. The ore is an intimate mixture of iron pyrites, with copper pyrites, galena, and blende, besides traces of almost all other metals, viz., gold, silver, mercury, bismuth, antimony, nickel, cobalt, manganese, arsenic, cadmium, and the newly discovered metals, thallium and indium, besides lithium. In 1872, these mines yielded 21,000 tons of raw ore from 237 mines, this ore being smelted at the works of Okerhütte for copper, lead, silver, and gold, while sulphate of copper and sulphuric acid are manufactured at the same time. The calcined ore is smelted with coke in low blast furnaces for regulus and blister copper, when the latter is for the greater part dissolved by sulphuric acid, and silver and gold obtained in the residue. Quite recently some silver extraction works by the chloride process have been started here.

Some copper is also produced by the silver-lead works of the Upper Harz Mountains, at Clausthal and Altenau; the quantity is, however, insignificant. We shall have to speak of this old mining district at another occasion.

On the southern slope of these mountains extends the great permian basin of Mansfeld and Thuringia, which contains between the lower permian sandstone and the magnesian limestone, the celebrated seam of copper schist, which, with great regularity, covers an area of several thousand square miles. Mining in this district, chiefly along the outcrop of the seam, is very old, and has been carried on by the once celebrated Counts of Mansfeld since 1512, but was brought to an entire standstill by the frightful Thirty Years War; since 1671, however, it has been taken up anew, in 1698 the first long adit was commenced, and in 1785 the first steam engine—then called fire-machine—for pumping, and in 1824 the first for drawing ore were started. Different companies worked here for many years independently of each other, but it is only since their consolidation has been effected that the Mansfeld Copper and Silver Company has obtained unprecedented financial results. The copper seam is only $24\frac{3}{4}$ in. thick, and 2 in. to 7 in. alone, with an average yield of 2 to 3 per cent. copper, are profitable, the product containing 0·5 per cent. of silver. From this it will be seen that the conditions under which the Mansfeld Company work are quite exceptional, and that its success is only due to the great regularity of the seam and the cheapness of its winning. The company's produce in 1872 was 5,500 tons of cake and slab copper, 45,800 lbs. of silver, and 4,550 tons of sulphuric acid, while the number of workmen employed reached the respectable figure of 7,900. The smelting process consists of a combination of blast furnace and reverberatory furnace operations. The raw ore or bituminous schist is first hand-picked and then burnt in large heaps, when it is smelted with coke and a small addition of slags in blast furnaces. The furnaces, which were in use since 1846, and of which we give a sketch in Fig. 1, Plate XXIV., were 20 ft. high, 3 ft. wide at the top, and 5·5 ft. at the boshes, and had two tuyeres, one on each side, while the tap hole is in front. They could smelt about 10 to 12 tons of burnt ore per day, and produced about 1 ton of copper regulus. Since 1867, however, blast furnaces of greater

capacity, and with six tuyeres, such as shown in Figs. 2 and 3, Plate XXIV., have been successfully introduced. These furnaces work with heated blast, and smelt four times as much as the former; they are 30 ft. high and 6 ft. wide, and provided with a gas collector at the top. The regulus, which collects on the bottom of the furnace, is from time to time tapped and granulated in a cistern by being run into water. This shot is dried, and goes to the calcining kilns of the acid works, and after having lost there the greater part of its sulphur it is remelted in a reverberatory furnace with sand, when white metal, almost free from iron and zinc, is obtained. We mentioned that this metal is argentiferous; it is, therefore, ground to a fine powder, and calcined in double-bedded calciners with great care, so as to change all sulphide of silver into sulphate, which may be extracted with hot water. The residue, which consists of nearly pure oxide of copper, is reduced into blister copper, and the latter is refined, partly in reverberatory furnaces, partly with charcoal in the German copper refining hearth, cake copper, in the shape of thin discs, being thus obtained. We may mention here that at the Mansfeld works until 1831 all the silver was extracted by the old Venetian liquation process with lead, subsequently by the so-called European amalgamation process, since 1843 by the chloride, and since 1848 by the hot-water process. We shall find occasion later on to again speak of these processes.

The royal Saxon smelting works of Muldenerhütte, near Freiberg, also produce some blister copper, which is refined at the copper mill of Grünthal, and from whence excellent specimens of copper slabs, plates, sheets, and bottoms were exhibited at Vienna. Aaron Hirsch and Son, of Halberstadt, showed very good copper tubes; the Crusau copper mill, of Flensburg, copper sheets and bolts for shipbuilding; Theodor Martin, of Koslow, near Gleiwitz, in Silesia, blast furnace tuyeres of copper; Dango and Dienenthal, of Siegen, and Herlitschka and Gobiet, of Düsseldorf, tuyeres of bronze. Phosphor-bronze was also exhibited by George Hoeper and Co., of Iserlohn, in Westphalia; and copper made from the grey copper ore of the Stahlberg and Schwaben mines, by the Cologne Muesen Mining Company, of Siegen. Lastly we may mention sulphate of copper from the Victoria Nickel Works, at Naumburg, and blue and green carbonate of copper from the permian limestone, and copper regulus by the "Stilles Glueck" Company, both of Silesia. This same formation contains copper and silver in many other localities, as at Wohlsdorf, in the Duchy of Anhalt; at Ilmenau, Eisenach, and Liebenstein, in Thuringia; at Stolberg and Seesen, on the Harz; at Frankenberg and Riechelsdorf, in Hesse-Cassel; and at almost all these places mining and smelting has been going on for some time.

Before concluding with Germany, we may mention here a matter brought to our notice, which has hitherto been little understood, viz., the welding of copper, an operation which can be performed just as easily as that of iron or steel. In order to unite two metallic surfaces, it is necessary that they should be absolutely free from oxide at the moment they are to be welded, a condition which can be assured only by adding a flux which will readily absorb any oxide as fast as it forms. Such a flux for iron is fine quartz sand; for steel, borate of soda or boric acid; while for copper, a mixture of 74·33 phosphate of soda, and 25·66 of boric acid will answer the same purpose. This powder is strewn upon the surfaces to be welded when the latter are red hot; the heat is then increased to a light cherry red, and the pieces are hammered with a wooden hammer, so as to press the welding faces against each other. The process, if properly done, is as perfect as with iron or steel.

The Austro-Hungarian Empire had at Vienna an excellent collection of exhibits relating to copper, though we had to look it up in half a dozen localities at least. The Imperial Copper and Silver Works, of Bixlegg, in the Tyrol, smelt argentiferous and auriferous copper ores, mostly grey copper ore or "fahlerz" which occurs upon numerous lodes in Tyrol and Salzburg, traversing the Triassic limestone and dolomite at Brixlegg, Schwaz, Kogl, and other places. The works produce annually about 250 tons of copper, 1,500 lbs. of silver, and 20 lbs. of gold, besides 90 tons of plates, sheets, and other wares. The ores are smelted into regulus in a blast furnace, with six tuyeres, 20 ft. 8 in. high, 4 ft. 11 in. wide at the top, and 3 ft. 11¼ in. between the nozzles;

it resembles much the type illustrated on Plate XXIV., as now being in use at the Mansfeld works. The copper regulus is calcined in a mechanical calciner, concentrated in a reverberatory furnace to white metal, which is desilverised, when the residue is reduced into blister copper and the latter refined. Sulphuric acid works will be put up in connexion with the calciners.

The Mitterberg Copper Company, of Salzberg, produces annually 200 tons of refined copper from copper pyrites, which is found in three lodes in the Devonian formation. These ores are roasted in open kilns and smelted in a blast furnace with five tuyeres for regulus containing 23 to 35 per cent. of copper; this is pulverised, roasted in a closed calciner, and reduced into raw copper in a small cupola, the product being then refined in an open charcoal fire into cake or rosette copper. An alloy of 5 copper and 24 nickel is obtained by resmelting the slags of the refining process.

Similar small copper works are to be found at Burgstein, in Salzburg, Kitzbuechl, in Tyrol, and Ahrnthal, near Brunnecken, while copper has also been extracted by Bischof's wet process in Carniola, at Skofie, with sulphuric acid, from ores containing 1·5 to 3 per cent. of copper, besides some carbonate of lime; but the process was not found to be a success.

In Hungary, the Upper Hungarian Waldbuergerschaft, or Citizens of the Forest, own several copper and silver works near Iglo. They smelt principally copper pyrites and grey copper ore, which contain some silver and mercury. The annual production is about 450 tons of copper, 2,050 lbs. of silver, and 315 cwt. of quicksilver. The latter is extracted during the first calcining of the ores, when it is driven out by the increasing heat and condensed in the upper strata of small ore, from which it is separated by a washing process. The ores are smelted in blast furnaces to obtain copper regulus and blister copper, when the latter is pulverised and subjected to an amalgamation with mercury for the extraction of the silver. The Royal Smelting Works, at Schemnitz, Kremnitz, Schmölnitz, and Tajowa, smelt similar ores, and the copper which they produce is rolled and hammered out at Neusohl and Felsöbanya.

The Transylvanian Copper Company, of Balanybanya, showed at Vienna copper ore, cake, and slab copper of excellent quality. The Austrian State Railway Company owns copper works at Dognacska and Moldova, in the Banat, and in 1872 produced with them 1,327 cwt. of copper, 1,839 cwt. of sulphate of copper, 625 lbs. of silver, 968 cwt. of litharge, 38,000 cwt. of sulphuric acid, and 1,800 cwt. of copper sheets and other articles. The total produce of copper in Hungary was, in 1871, 1138·25 tons, the greater part of it being obtained at the Royal Works, near Schemnitz.

The Totoseh Copper Company and Josef Theiner, of Kaschau, exhibited also some copper ore. Regarding manufactured copper articles we need only mention Michael Fabritius, of Hermannstadt, Brothers Sternberger, of Windisch-Feistritz, for copper nails and ships' sheathing, George Zugmayer and Sons, of Waldegg, for excellent copper sheets weighing over 5,000 lbs., and Ch. and H. Chaudoir, of Simmering, near Vienna, for excellent samples of refined copper tubes, sheets, plates, bottoms, &c. Of brass articles we may note those of the Oed Metal Works, Habtmann, of Frauenthal, Klein, of Reichramming, and the Achenrain Works, in Tyrol.

In the exhibition of Russia we met with several noteworthy copper exhibits; before all with those of Prince Paul Demidoff, of Nischnei-Tagilsk. His works at Meidno-Roudiansk smelt, in a species of modified Raschette furnaces, which will be described hereafter, yellow and carbonate copper ores with hot blast, into a regulus containing 35 to 40 per cent. of copper. This regulus is calcined and melted to raw or blister copper, which is then refined in a reverberatory furnace or in the refining hearth. The quality of the product is excellent, and it always commands a high price in the market. Next came similar samples, shown by Basil Paschkoff from his works at Bogojarlensk and Werchotoursk, where oxidised ores are smelted for blister copper in one operation with charcoal furnaces. The annual produce is 210 tons of cake copper of renowned quality. The Jougoff smelting works produce 160 tons from similar ores, which all come from the Permian formation in the district of Perm, while ores and cake copper and plates were also exhibited by Countess

Stenbock-Fermor, from Wersch-Iselsk, and from the Permian Copper Works. Siemens Brothers showed copper pyrites, regulus, and cake copper from Kedabeg, in the Caucasus. Copper ores from Greece were represented by the Greek Metal Company of Attica, and from Turkey from the vilajets of Trebizond and Sivas, in the Mutessarif of Karahissar, while metallic copper was shown from Adana, Edirne, Diaberkir, from several smelters, and Janina, in Albania. The Government collection of China contained also many copper exhibits, while Japan was very well represented by ores of sulphide of copper, malachite, auriferous copper ore, raw copper, refined tile copper, bars, and wire.

Looking finally at America, we found nothing from Chili; but some samples of copper ore and of sulphate of copper from Aroa, in the state of Yaracuy, in Venezuela. The considerable copper industry of North America was also entirely unrepresented, with the exception of a few rare specimens in a collection exhibited by Mr. Guido Kuestel. There were some new copper ores from Sonora and California, the former a sulphide of copper and lead, the latter a sulphide of copper and antimony or fahlerz, with silver worth 200 dols. per ton. Another curious ore was a green silicate of copper, which looked like a green blast-furnace iron slag, and did not resemble the well-known Beaumontite of South Australia. It is much to be regretted that the United States gave no other illustration of copper, as they own a very great wealth of this metal in Michigan and on Lake Superior.

Lead.

Great Britain and her dependencies—although their annual production of lead, litharge, white and red lead, exceeds 70,000 tons—gave no account whatever of her lead-smelting industry, if we except a small ingot of lead in the Indian collection, which was arranged by Professor Oldham, and which we had occasion to mention when speaking of the copper and mineral fuel exhibits. In the French department we found, however, a very interesting exhibition by Thomas Payen, of Marseilles, who illustrated an entirely novel metallurgical process for the treatment of lead containing much arsenic and antimony (the presence of which would to a great extent prevent the extraction of its silver), and for the production of soft lead. M. Payen calls his purifying process "natrometallurgy," because the principal purifying agents used in it are caustic and carbonate of soda. The impure lead is melted with alkali in large Pattinson pots, and a steam jet introduced, when the impurities will rapidly oxidise, rise to the top, and combine with the caustic soda, while lead is only to a small extent oxidised, and silver and gold not at all. M. Payen made the best use of this simple process when dealing with Greek slag lead from Laurion, in Attica, containing 6·5 per cent. of antimony, 3·0 of arsenic, 0·5 of copper, and 1 to 2 per cent. of iron and sulphur. In his works at the Prado, near Marseilles, a charge of 6 tons is heated in a pot to a dark red heat, or about 720 to 900 deg. Fahr., and is four times treated with a dose of half a ton of soda, when the molten metal is agitated by either dry steam or blast. The first slag thus obtained, contains nearly all arsenic, iron, and sulphur, the second and third the rest of the arsenic, and almost all the antimony, and the fourth the rest of the latter and the copper. The whole process lasts about 20 hours, when the purified lead is desilverised by the Parkes zinc process, and the whole amount of silver concentrated in about 4 cwt. of dross or scum. The lead still contains after this treatment 0·002 to 0·003 per cent. of zinc, which is removed by melting it together with 1 to 2 per cent. of soda. The slags, which contain arsenic and antimony, serve as a raw material for the production of arsenate of soda, and of metallic antimony.

Messrs. Laveissière and Son, of Paris, exhibited at Vienna very good specimens of lead wares, such as plates 11 ft. 2 in. by 39 ft. 4 in., and sheets for sulphuric chambers, 98 ft. 6 in. long and 3 ft. $3\frac{3}{8}$ in. wide, also lead tubing of various shapes and calibres, and a water pipe 9,186 ft. long, pressed in one single piece.

Spain exhibited numerous samples of lead ores, most of them argentiferous; the principal exhibitors being Amadeo Salazar, of Bailen, the Distrito Minero

of Madrid, the Potosi mine of Granada, the Mining Academy of Madrid, the General Customs Direction, the San Juan and Anna Company, of Mazarron, in Murcia, and the El Traile and Bella Union Companies of Carthagena. The greater number of lead ores are derived from the neighbourhood of Carthagena, Almeria, Granada, Linares, Badajoz, Bailen, and Zamora. In Portugal we found a few samples of argentiferous lead ore shown by José Maria d'Almeida of Beja, the Vicomte de Freixo, of Porto, and the Lusitanian Mining Company, of Albergaria a Velha. Italy was very well represented through numerous specimens. Domenico Santelli exhibited samples of dressed and washed galena from Vinadio, near Cuneo, Chevaliers Bianchi and Franchetti silver lead ore from Callizano near Genoa, and Messrs. Bolla and Locatelli similar ores from Brusimpiano, near Como. Galena, silver lead, pig lead, and silver were very ably represented by M. Blanchard, Director of the Societa del Bottino, at Stazzema, near Lucca, the best samples, however, came from the island of Sardinia. From this island we found ores exhibited from the mines Gennaman and Jugurtosu by the Gennaman Mining Company, ores and smelting products by the company of Montesanto at Iglesias, ores from the Montefidano mines, from those of Monteponi, the Company des Bons Amis, Messrs. Henfrey, Etchats and Company, the Gonnessa Mining Company, the Italian Spanish Mining Company, and others; all from Inglesias, near Cagliari.

Sweden showed some very good samples of rich silver lead ore from the celebrated mines of Sala, and Norway the same from the Jarlsberg mines, near Drammen, by the Jarlsberg mining Company. At both localities the ore is broken from beds or lodes in the Silurian limestone. In the Belgian department, the Bleyberg-ès-Montzen Company illustrated the smelting and refining processes of its works at Montzen, near Liége, by a good collection of samples of raw and dressed ores, smelting products, and double refined lead, which is guaranteed to contain not more than 0·00488 per cent. of foreign substance, that is, to be almost chemically pure.

We now come to the German Empire, which with regard to the production of lead occupies a high place, its annual quantity being nearly 70,000 tons of lead and litharge, while during late years it has been rapidly increasing. We shall begin our review with the Rhenish provinces, in the department belonging to which we found very fine specimens of galena in large cubes, carbonate of lead and copper pyrites exhibited by the New Hope lead mine of Bleialf, near Prüm, which was worked by the Romans, and which at present produces annually 2,500 tons of galena, a quantity which will be considerably increased when the new 400 horse power Woolf pumping engine is set to work. The lodes of this mine intersect the lower Devonian strata.

We noticed next the Mechernich Mining Company of the Meinerzhagen Bleiberg, which produced in 1872 1,500 tons of pure galena, and 14,750 tons of argentiferous smelting ore. The mines are partly Roman, and have been extensively worked since 1629; they have reached their present prosperity since their consolidation in 1857. The ore deposits are here of rather an exceptional kind; two series of strata belonging to the new red sandstone, one 62 ft. thick, the other 89 ft. 3 in., are all over spotted with small nodules of lead ore, which are called "knotten," of $\frac{1}{25}$ in. to $\frac{1}{3}$ in. in diameter. The sandstone contains only from 0·15 to 1·5 per cent. of lead with 0·027 per cent. of silver, but it is so friable that it is easily crushed to fine sand, when the more coherent nodules are simply sifted out and then purified by a regular mechanical washing process. The metalliferous beds of this district extend over a belt along the Devonian rocks over six miles long, and contain an enormous quantity of metal. In these mines boring machinery and underground locomotives are largely employed, and 1,000 cubic metres (35,316 cubic feet) of ore ground have to be shifted in every watch of 10 hours. The dressed lead ores are roasted in a calciner, 78 ft. 9 in. long, and smelted in blast furnaces for silver-lead and regulus. The silver is extracted by the Parkes zinc desilverising process, and the lead refined with steam. The mines give employment to 2,700, and the smelting works to 228 workmen.

The Stolberg Lead Mining and Smelting Company, of Aachen, has its works near Aachen and in Westphalia. They produce lead, zinc, silver, and

iron pyrites, and give employment to 3,500 men. The Rhenish works at Stolberg are supplied with lead ore from lodes which occur on the borders between the upper Devonian rocks and the mountain limestone, the principal mines being Diepenlinchen and Glücksburg, while the mines of Dornberg and Bastenberg, near Ramsbeck, supply the Westphalian works. The total production of the company is 13,000 tons of lead, and 13,600 lb. of silver. The lead ore is roasted in 20 calciners, reduced in 12 blast furnaces, and the lead obtained desilvered both by the Pattinson and the Parkes processes.

The Rhenish-Nassau Mining Company, of Stolberg, exhibited at Vienna lead ores in the raw and dressed state, and pig lead and silver from its works at Stolberg and Holzappel, in Nassau. The former were, in 1872, supplied with 7,000 tons of ore from the company's mines near Stolberg and Bensberg, which yielded 4,850 tons of lead, and the latter works received from the lodes at Holzappel and Obernhof, 7,200 tons of dressed lead ore, from which were extracted 1,200 tons of lead, and 2,400 lbs. of silver, by the Pattinson process. The company employs about 1,200 miners and smelters. Herbst and Co., of Call, in the Eifel Mountains, showed lead from their works at Schliessemaar, where they smelt ore from the Munsterfeld mines, near Stolberg, and Gertrudsegen, near Much. The annual produce is about 600 tons of pig lead; the silver is extracted by means of zinc, and the lead refined with chlorides. On the right bank of the Rhine we find lead ores produced in the Siegen district, together with iron ores, by the Wissen Mining Company, and by the Cologne Müsen Company, the latter raising about 1,600 tons of galena and fahlerz, which are smelted at the works of Lohe, near Siegen, and yield about 400 tons of lead and litharge, and 1,500 lbs. of silver, besides some copper. The Ems Lead and Silver Works at Pfingst wiese, near Ems, in Nassau, have smelted the mineral of their mines Mercur and Bergmannstrost since 1749, and in 1872, they raised 11,500 tons of dressed ores, partly calamine ore, blende, copper ore, and iron ore, partly silver lead ore. The former are sold, the latter smelted at the works by being roasted in double calciners, and reduced in Raschette blast furnaces, when the lead is desilvered by the Parkes process. The annual production was 1,800 tons of lead, 1,700 tons of litharge, and 6,100 lbs. of silver. The works give employment to 1,500 men.

From the Rhine we turn to the Lower Harz, where the celebrated mines of the Rammelsberg, near Goslar, already mentioned by us, produce annually 9,300 tons of lead ore, which is smelted at the works of Okerhütte. Of much greater importance for lead, however, is the Upper Harz district, near Clausthal. Numerous important lodes here traverse the lower carboniferous or culm strata, giving rise to a very extensive mining industry which has existed since the end of the twelfth century, but which, however, twice succumbed to the political and religious disturbances of Germany, namely, in the middle of the fourteenth century, and during the Thirty Years' War. Deep and long adits were commenced here in 1548 and 1573, and these drained large districts, and opened much ore ground. A new and flourishing era began with the eighteenth century, when a general system of collecting and utilising the surface waters by means of dams and reservoirs for the benefit of the pumps, was introduced. The deep George adit, which is navigable, was driven between 1777 and 1799, the deep water level in 1803, and the Ernest-Augustus adit in 1851. Water pressure pumping engines were introduced in 1835, and the man engine, to lift the miners out of the shaft, was invented here in 1833, by bergmaster Dörell, and first carried out in the Spiegelthal Hope mine. The mines and works of the Clausthal district are driven at the expense of the Government, and now give employment to over 5,000 miners and smelters. The mines yielded in 1872, 154,622 tons of raw ore, which, stamped and dressed by means of much improved machinery, yielded 13,546 tons of dressed ore. Great pains are being taken here with regard to ore dressing, and a large dressing mill has just been started at Clausthal with steam crushers, continuous jigging machines, rotating buddles, side blow percussion tables, and other apparatus, which will produce 15,000 tons of washed ore per annum. The lead ore is smelted by the works at Clausthal, Lautenthal, and Altenau, and yielded in 1872, 7,930 tons of pig lead, 47·5 tons of litharge, 400 lbs. of gold, and 45,900 lbs. of silver, while

the works at Andreasberg smelted principally rich auriferous and argentiferous ores, mostly derived from Mexico.

The smelting process employed in the Upper Harz district, since the beginning of this century, has been the iron reduction process with metallic iron, and since 1865 with rich iron slag in blast furnaces, when the sulphur of the ore combines with the iron and metallic lead will be precipitated. It was materially improved by the introduction, in 1864, of the Raschette blast furnace, of which furnace we give a sketch in Figs. 4 and 5, Plate XXIV., one figure being a half section and half elevation, the other a plan of two furnaces. The latter are 6 metres (19 ft. 8¼ in,) high, and have an oblong section, being 2·25 metres (7 ft. 4⅛ in.) long and 1·5 metres (4 ft. 11 in.) wide at the top, and 1 metre (3 ft. 3⅜ in.) between the tuyeres. There is on each long side a row of five tuyeres, which are so arranged, that each blows into the space between the two opposite tuyeres; at each small end there is a taphole and fore-hearth. These furnaces are the invention of Vincenz von Raschette, Major-General of the Russian Mining Engineers, who carried them out for copper and iron smelting at Prince Demidoff's works in Russia, whence they were introduced into Germany by Charles Aubel.

The success of the Raschette furnaces led to the improvement of the old blast furnace, and since then large round cupola furnaces, of the shape of an inverted cone, have been successfully used with four, five, and eight tuyeres. Of these latter furnaces we give a sketch in Figs. 6 and 7, Plate XXIV., our views being a section and plan. These furnaces are 18 ft. high, 6 ft. 3 in. wide at the top, and 3 ft. 11½ in. wide between the tuyeres; they have a closed top, while the gases and the ore dust are carried through canals to flue chambers, where the dust settles down.

The lead obtained was formerly desilverised in the cupelling furnace, but in 1864 the Pattinson crystallising process, and in 1868 the Parkes zinc process, were introduced. And here we may be allowed to say, in parenthesis, that the claim, which is made by some German metallurgists—as, for instance, Wedding and others—for the late Karsten, as the inventor of the zinc desilverising process, is entirely unfounded; Karsten had never carried it out before Parkes and Gurlt published the fact, in 1851, that silver will combine with zinc in preference to lead. Even if Karsten had known this fact, he certainly never published it before 1852, and therefore he is not entitled to claim any priority, or to have his name in any way connected with the process.

From the exhibits of the Upper Harz we came to those of the Royal Saxon Smelting Works, at Freiberg, which we found arranged by the side of the pyramid which represented the Mansfeld Copper Company, the Upper Harz, the Lower Harz, and the Tarnowitz-Friedrichshütte. The Saxon Works exhibited gold, silver, lead, litharge, sulphate of copper, arsenic, and sulphuric acid. The grey gneiss of the Saxon Erzgebirge contains numerous metalliferous lodes, and in the immediate neighbourhood of Freiberg, 800 of them are grouped in four systems, which extend over 30 miles. Mining began here as early as 1169, and since 1181 it has been brought into a flourishing state by the immigration of miners from the Harz. The deep Prince's adit had already, in 1384, a length of 2,000 fathoms, but the terrible Thirty Years' War brought this mining district also to the verge of ruin, and it was only very gradually that it was able to recover. The first water-pressure pumping engine was erected here in 1767, and the first man engine in 1856.

The minerals of the lodes are principally silver, lead, and copper ores mixed with blende and iron pyrites; they are crushed and washed in numerous dressing mills, while the stampmill, with a constant flow of water, and the jigging machine were introduced as early as the beginning of the fifteenth century. The produce of the mines was, in 1870, over 25,000 tons of washed ore, from which, at the Muldenerhütte and Halsbrück Smelting Works, the following products were obtained, viz., 400 lbs. of gold, 89,300 lbs. of silver, 3,750 tons of lead, 550 tons of litharge, 1,350 tons of sulphate of copper, and 800 tons of white, red, and yellow arsenic, together with 9,400 tons of sulphuric acid. The ores are at presented roasted in calciners and smelted with coke in blast furnaces for lead and regulus; from the former the silver is separated by the Pattinson, from the latter by the sulphuric acid process. The

ore smelting in the sixteenth century was done in low cupolas, or "krum-oefen," but since 1588 in high blast furnaces, and since 1866 in large round furnaces, similar to those at Clausthal. Coke was introduced as fuel in 1823. The silver has been extracted from all ores which contained little lead by the amalgamation process since 1790, by the Augustin chloride process since 1843, and by the sulphuric acid process since 1860. The advantages of the round blast furnaces are conspicuous. While the old blast furnaces, with two tuyeres in the back wall, could only smelt 10 tons of ore and flux per day, the round furnace, with four tuyeres, does 30 to 35 tons, and that, with eight tuyeres, 65 tons in an equal time, while 1 lb. of coke is capable of smelting 7·3 lbs., 10·04 lbs., and 13·00 lbs. of mixture in the three furnaces respectively.

Lead ore was also shown at Vienna from Upper Silesia, where it generally is found, together with calamine, at the mines Scharley, New Helen, Maria, Elizabeth, Clara, and Samuelglück, near Beuthen. These ores are smelted at the Paulshütte Lead Works, near Myslowitz, by George von Giesches'heirs, in blast and reverberatory furnaces, and give an excellent product. This ore, as well as that of the Friedrich mine, near Tarnowitz, belongs to the triassic dolomite, where it is found in irregular beds. The latter mine produced, in 1872, 10,850 tons of ore, from which, at Friedrichshütte, 5,750 tons of lead, 1,050 tons of litharge, and 12,200 lbs. of silver were obtained. The smelting is done by the iron-reduction process, and the desilverising of the lead by the Parkes process. The Pattinson process was tried here in 1837, the Parkes process in 1852; they were, however, only introduced, the former in 1861, the latter in 1869, owing to the indecision and want of method of the experiments. The assertion that Karsten here invented the zinc desilverising process, is simply a misstatement, as we have shown above.

When we desired to see what the Austro-Hungarian Empire had exhibited at Vienna with regard to her lead industry, we had to look out for it at different places, but we found much in the pavilions of the ministry for agriculture and of Carinthia, while some exhibits were scattered about in the Austrian and Hungarian courts for raw materials. In the Austrian section were, amongst the most noteworthy specimens, those of the Imperial mines and the Charles Borromœus Silver and Lead Company of Przibram in Bohemia. Mines have been worked here since about 1340 upon north-south lodes, which traverse silurian greywacke and slate, and which when following certain dykes of greenstone generally become very rich. There are now 34 such lodes known and opened by 14 shafts, of which the deepest has reached to a depth of over 460 fathoms, where a constant temperature of the rock of 43·66 deg. Cels. (110·59 deg. Fahr.) may be observed. The richest is the Adalbert lode, which is principally composed of carbonates of lime and iron, quartz and sulphate of barytes, which accompany the metallic ores, consisting of galena with 0·11 to 0·55 per cent. of silver, argentiferous blende, and occasionally copper ores, bournonite, native silver, &c. The lodes are generally composed of gossan or oxides of iron from the grass to a depth of 20 to 60 fathoms, and their average value is from 14*l.* to 15*l.* per square fathom. There is water and steam power machinery for pumping and drawing of an aggregate strength of 1,200 horse-power. The quantity of ore raised in 1871 was 150,000 tons of all kinds, which were stamped and washed at four large dressing mills, yielding 3,100 tons of smelting ore, with 20,400 lbs. of silver and 1840 tons of lead. The smelting works, however, produced in the same year 32,548 lbs. of silver, 29,071 cwt. of litharge, and 8,947 cwt. of soft and hard lead. The ore is roasted in open calciners and closed kilns, and then reduced in blast furnaces, of which the newest are 26 ft. 11 in. high, with a section of 52·7 square feet, and provided with 7 tuyeres. The silver is separated by cupellation in large furnaces, which hold 25 tons of lead, and are provided with four fire-grates and flue chambers.

The specimens and models which were exhibited in the pavilion of the ministry of agriculture at Vienna, were very remarkable. From Mies, in Bohemia, where mines have been worked since 1131, samples of lead ore and lead were exhibited by Josef Graf, and the mines of Frischglück and Reichersegen. The lodes, which vary in thickness from 1 in. to 3 fathoms, are found in Cambrian slates, and contain argentiferous galena.

The province of Carinthia showed her mineral treasures to advantage in its own pavilion. Struggl's heirs of Raibl showed lead ores, and a model of a rope tramway, which is in operation at their mines, while the Imperial Mine Administration of Raibl made a very complete exhibitition of their productions in the ministerial pavilion. These latter lead mines were worked already in Roman times upon veins which occur in triassic limestone, and partly take the appearance of real ore beds, partly that of an irregular impregnation of the Hallstad limestone, owing to the influence of some distinct fissures, through which the metalliferous fluids appear to have circulated. The galena is almost devoid of silver, and after a mechanical preparation the ore is smelted in Carinthian reverberatory furnaces, which produce a very pure lead with only traces of copper, iron, and antimony, and from 0·118 to 0·382 per cent. of sulphur. The Raibl Works employ about 300 people, and produce annually 300 tons of lead, besides some calamine and blende. The Bleiberg Union Company, of Klagenfurt, have their principal mines at Kreuth, Bleiberg, and Heiligengeist, near Villach, in a thick lias limestone, which contains numerous veins of varying thickness. The ore is dressed and smelted in Carinthian furnaces in eight works, which produce 1,700 tons of lead, part of which is manufactured into litharge, red lead, shot, pipes, and plates of various sizes. The company gives employment to 1,500 hands. Other exhibitors from Carinthia were Count Gustav Egger, of Zauchen, Theodor Aichelburg, of St. Stephan-on-the-Gail, Josef Rainer, of Klagenfurt, John Rohrer, of Lind, near Sachsenburg, Von Wadley, of Klagenfurt, and Baron May de Madys, of Neuhauss. The Knapause Lead Company, of Laibach, showed exhibits from its mines and smelting works, which produce 150 tons of lead per annum, while the Silberleiten Company, of Bieberwier, in Tyrol, showed some lead ore. The lead lodes in Carniola and Tyrol are of a similar kind to those above described.

Hungary showed few exhibits connected with the metal under notice. Only the Ivanec Mining and Zinc Company, of Croatia, and Mauthner and Son, of Beslinac, on the military frontier, exhibited specimens of lead ore and lead, while the Royal Hungarian Smelting Works illustrated by pedigrees and samples their operations at Nagybanya, where the Parkes process has of late been introduced.

Turkey, though still very backward with her mining industry, exhibited lead from the vilajet of the Dardanelles, and from Erzeroum in Asia Minor, and silver lead ore from Salonica and the mines Lekenet and Tan Zampara in the vilajet Aïdin, in Asia Minor. In the Greek section were exhibits by A. Kordellas, of Attica, who showed hard and refined lead, and by the Metallurgical Antiparos Company, namely, galena and sulphur. In the exhibition of Siam we found a few specimens of lead and silver lead and pig lead from Japan. North America was represented by the Mineral City Mining and Smelting Company, of Illinois, with lead ore, fluorspar, silver lead, and pigs of lead of great purity; by the Grand Pier Mining Company, of the same state, with galena; and by Santee and Wagner, of Rolla, in Missouri, by lead and copper ores. In the collection of Mr. Guido Küstel, we found some rare lead minerals, namely, natural oxide of lead from Arizona, which was previously only known from Mexico; a green argentiferous silicate of lead, and a light yellow antimoniate of lead and silver from Nevada From South America there were samples of galena from the mine El Grap Pobre, at Carupano, in the state of Cumana, and from Tipe, near Caracas. in Venezuela, and of argentiferous galena, exhibited by Domingos Moitinho, from the mines of Iporanga, province of Santo Paulo, in Brazil.

Gold.

Before passing on to review the gold exhibits, we may be allowed to say a word about the relative value of that metal and silver. When, since the gold discoveries in California, about 1848, and in Australia in 1852, the quantity of that metal, which was annually produced, began to increase enormously, it was feared that the price of gold, as compared with that of silver, must fall. This, however, has not been the case in any remarkable degree. While in 1848 the value of one pound of gold was equal to 15·81 lb. of silver, it

certainly declined in 1853 to 15·20 lbs., but since then it has kept up steadily to over 15·50 lbs., and it is now over 15·50 lbs. of fine silver. In former times the difference was very much greater. In the year 1500 the value of gold was equivalent to 10·50, in 1600 to 11·60, in 1650 to 11·13, in 1700 to 14·90, in 1750 to 14·93, and in 1800 to 15·42 lbs. of silver, thus showing a constant increase, while the value of silver was successively reduced.

In beginning our review with Great Britain, we can of course look for gold only amongst the exhibits of our colonies. In the Indian Department we noticed samples of alluvial gold from Maunbhoom and Chaibassa, in Bengal, from Upper Assam, and auriferous quartz from Malabar; while from the Cape Colony there were similar samples produced by N. Adler, of Port Elizabeth, and Sir John Swinburne, of Capheaton, Newcastle-on-Tyne, who also exhibited gold quartz and gold in bars. In Cape Colony the newly discovered gold fields of the Transvaal Republic and of Natal, contain lodes of rich gold quartz, which yield 70 oz. to the ton. From our Australian colonies, we found in the department of Queensland a large nugget of gold, weighing 104 oz., which still showed the traces of the lucky digger's pick. The value of the Queensland goldfields is, of course, variable, as in the districts of Etheridge, the gold quartz yields on an average 0·0076, in Gilbert 0·0073, in Gympie 0·00816, in Ravenswood 0·00917, and in Charton Towers and Broughton district 0.0178 per cent of gold. In Victoria the average yield of 900,000 tons of quartz was 0·0037 per cent. In that colony the diggings in the alluvium give way more and more to quartz mining; however, the biggest lumps or nuggets, which were instructively represented by models exhibited by the Government Mining Department of Melbourne, were found in the former. Thus, the "Welcome," found in 1858, at Bakery Hill, Ballarat, 180 ft. below surface, weighs 2,195 oz., and the "Viscount Canterbury," raised 1870, at Join's Paddock, Berlin Diggings, 15 ft. from surface, is 1,105 oz. in weight. There were in the first half of 1873, in Victoria, 35,806 alluvial miners, who won 123,643 oz., and 17,079 quartz miners, who produed 159,605 oz. of gold, over 14,000 men being Chinese. The quartz lodes or reefs are regularly worked with shafts and pumping and drawing machinery; the deepest mine, worked by a Stawell company, is called the "Magdala," and has reached a depth of 1,225 ft. from surface. The Victorian exhibits comprised also some samples of gold quartz from the Ajax Gold Company of Castlemaine and the Golden Fleece and the Husters Reef Company of Sandhurst.

New Zealand made, at Vienna, a good show of her gold production, of which the total yield, up to 1873, amounted to 6,718,248 oz., worth 25,814,260*l*. About 734,269 oz. of this quantity were obtained by lode mining in igneous rocks of the tertiary period, on the North Island, while by far the greater mass came from alluvial deposits, connected with metaphoric rocks on the South Island. The principal alluvial gold deposits are in the provinces of Otago, Nelson, and the county of Westland. The gold always contains, silver, sometimes one-third, and the metals are separated by dissolving the gold in a solution of chlorine, when chloride of silver is left in the residue, and metallic silver is obtained through reduction with iron, by the use of a galvanic battery and acidulated water. The gold, which is precipitated from the solution and melted into bars weighing as much as 375 oz., is 99·42 per cent. fine. The quartz reefs or lodes are principally worked in the Inangahua and Lyell districts, province of Nelson, and 85 tons of quartz of the Alpine reef, yielded 860 oz. of fine gold. A bar of unrefined gold from Hokitika contained only 0·037 per cent. of silver and 0·001 of copper, while another from the Thames district, Auckland, was composed of 65·05 gold, 33·90 silver, 0·45 copper.

France also showed some gold from her colonies, there being some fine nuggets from Guyana, where the annual produce comes up to about 80,000*l*. per annum, and some from New Caledonia. Spain exhibited gold quartz from the Jadena mines, province of Toledo, containing 13 oz. to 54 oz. per ton, and Italy was represented by Ludovico Rocco, who exhibited auriferous ores from the mines Piandello and Alpetto, at Domo d'Ossola, near Novara.

In the German section, we found a few gold exhibits from the smelting works of Goslar, which produce 800 lbs. per annum, as well as from Clausthal and Freiberg, which have annual productions of 200 lbs. and 400 lbs. respectively.

In the year 1871, the yield of gold in the Austro-Hungarian Empire was 2,802 lbs., the greater part of which came from the Royal Hungarian Smelting Works. There are, however, some very old, even ante-Roman gold mines upon quartz lodes in gneiss in the duchy of Salzburg; but their yield has very much declined in our times, the Goldberg of Rauris having produced only 14·1 lbs. of gold in 1871, and the Rathhausberg at Gastein still less. The gold is extracted from the crushed quartz by amalgamation in Hungarian quick mills. From the gold mine of Döllach gold quartz, maps, and samples of galena were exhibited by Baron May de Madys, gold and silver ores by John Rohrer, of Lind, near Sachsenburg in Carinthia, and ores, amalgamated gold, fine gold, and fine silver by the Gastein-Rathhausberg Company of Oberndorf in Salzburg. The government mines of Transylvania at Veröspatak, Offenbanya, Zalathna, and Nagybanya are the chief producers of this metal, the mining directors of the last place showing a good collection of gold from Felsöbanya and Abrudbanya, and of gold-tellurium from Nagyag and Offenbanya. The gold is generally extracted in iron quick mills by amalgamation, only a part being won from regulus, as in the Upper Hungarian works.

Russia, though she got in 1871, 78,621 lbs. of gold from her diggings and gold mines in the Ural Mountains and Siberia, was only represented by the Jekaterinburg mining district, in the Perm government, there being shown samples of gold, gold sand, and drawings and models of the gold-washing machinery, as employed in that district. In 1870, Russia had 1,126 gold diggings and mines, which gave employment to 68,000 workmen. They are mostly situated in Eastern Siberia, in the districts of Slatoust and Nertschinsk, and near Jekaterinburg and Nischnei Tagilsk, in the Ural, while the gold mines are in the Altai, near Nertschinsk and at Beresow. The gold sand is first riddled with water and then swept over an inclined plane or buddle where the heavy material settles down. This is then rewashed with mercury and the gold freed from the amalgam by distillation. The Siberian wash gold contains 10 per cent. of silver.

Turning lastly to America, we found some exhibits of gold quartz by Mohrhardt and Robinson, of Bethany, in Pennsylvania, and in the interesting mineral collection of Professor Guido Küstel, of Utah, were specimens of gold and tellurium-gold from Jefferson Canõn, in Nevada. British Columbia, which in 15 years, in the gold district of Frazer River and others, has produced gold worth at least 45,000,000 dollars, did not show anything, neither did California. From Venezuela, however, we found rich gold quartz from the mines Upata and Caratal, in Guayana, which produced in 1867, 17,118 ozs., in 1868, 17,053 ozs., in 1869, 22,575 ozs., and in 1870, 35,713 ozs. of gold. Finally Brazil was represented by Dr. Da Continho, of Rio, with palladium gold from Gongo Soco, in Minas Geraes, and wash gold, in the shape of scales, wire, and little discs, and by the Imperial Museum and Dr. Da Silva with gold nuggets, gold dust, and diamonds in their native rock, the itacolumite, which much resembles a brownish, fine-grained kind of mica schist.

Platinum.

As for our last precious metal, platinum, we looked in vain for samples from Russia, which is the chief producer; but in 1871 she only got 4,100 lbs. of this precious and valuable metal. The platinum diggings of Russia are near Bogoslowsk, Miask, Newjansk, and Nischnei Tagilsk, in the Ural Mountains; they were discovered in 1824, and at six places in 1868, 1869, and 1870 from 494,000, 367,000 and 263,000 tons of sand, 6675, 7,770, and 6,455 lbs. of raw platinum were obtained respectively. The metal contains always some other substances; thus Le Play found in a sample from Nischnei Tagilsk 75·1 platinum, 1·1 palladium, 3·5 rhodium, 2·6 iridium, 0·6 osmiridium, 2·3 osmium, 0·4 gold, 1·0 copper, and 8·1 iron. The raw metal is almost entirely sold to England and Paris, at a price of about 14*l.* per pound of pure metal. It is there refined before it can be worked up into manufactured

articles. Of such objects we found some chemical apparatus exhibited by Demoutis-Guenesser and Co., of leading position in Paris, and Heräus, of Hanau, in Germany, the former firm also showing metallic ruthenium and palladium. The prize for such work, however, is due to Johnson, Matthey, and Co., of Hatton Garden, London, who exhibited a splendid platinum still for sulphuric acid, worth about 3,500*l*. There was also an ingot of palladium worth 2,000*l*., which had been extracted from a mass of platinum of a value of over one million of pounds. Very remarkable also was a nugget of platinum, weighing 4,728 grammes, in a collection of platinum sand and washed platinum, while the alloys of iridio-platinum and *platino-iridium* deserved great attention, the latter being intended for normal metres, and being smelted in lime crucibles, after the method of Deville. Amongst the exhibits from New Zealand was also a sample of ferriferous platinum sand from Orepuki diggings, north shore of Foveaux Straits. The extracted metal contains 85·37 platinum, with a little iridium, 13·65 iron, and 0·98 gold and quartz; in the Imperial Brazilian Museum's collection were also some samples of platinum sand and platinum from Minas Geraes, in Brazil, where its original matrix is syenite. The annual produce of platinum in Brazil, Columbia, California, and Borneo seems not to exceed about 1,000 lbs.

Nickel.

Since coins of nickel have been introduced in Belgium, Switzerland, and Germany as fractional currency, the demand for this metal has greatly increased, and also its price, and this cannot fail to greatly influence all other manufactures in which nickel is used as an alloy with copper and zinc, such as German silver, argentine, alfenide, and others. The price, which was about 4*s*. per pound a couple of years ago, has of late risen to 14*s*. and 15*s*., and as the annual production of nickel is but about 500,000 lbs. in Europe, and 200,000 lbs. in America, it is not likely to recede much. Neither England, France, Spain, nor Italy, showed nickel exhibits at Vienna, although England produces a considerable quantity at Swansea and Birmingham from imported Norwegian and South American ores. Belgium owns nickel works at Val Benoit, near Liége, where Messrs. Levi and Kuntzel extract that metal from regulus, which is made at Varallo, in Piedmont, from magnetic iron pyrites, containing 1·5 to 2·5 of nickel and cobalt.

In the German section at the Vienna Exhibition we found nickel exhibited by Fleitmann, and Witte, of Iserlohn, in Westphalia, and by the Victoria Nickel Works, of Naumburg, in Silesia. Both seem to smelt principally imported ores or regulus, though the first-named firm seems also to receive part of its ores from some Rhenish and Westphalian iron and lead mines. The once important nickel works of Dillenburg, in Nassau, have been stopped for some years, probably owing to the exhaustion of the ore, which was found at Nanzenbach, connected with serpentine and diabase, and contained 2 per cent. to 5 per cent. of nickel, together with some copper. A similar fate seems to have befallen the nickel works of Gladenbach, Grand Duchy of Hesse, where nickel ores were extracted from similar igneous rocks. In the Grand Duchy of Baden nickel ores are found at St. Blasien and Totmoos, these consisting of magnetic iron pyrites with some copper pyrites, and containing 2·5 to 5·5, and even 12 per cent. of metal. The ore is found in hornblende gneiss, and connected with rocks of gabbro and serpentine; it is smelted at St. Blasien in blast furnaces, into a regulus, which is calcined, remelted, and at last refined, so as to yield metal containing 60 to 63 per cent. of nickel, 24 to 27 per cent. of copper, and only 0·3 to 0·5 per cent. of iron. This regulus is sold to the Victoria Works of Naumburg. These works made a very good show of metallic nickel in cubes, and of sulphate of copper, at the Exhibition' and of late they have made themselves independent for raw materials by buying the Sagmyra nickel mines in Sweden. The Mansfeld Copper and Silver Company, and the Goslar Smelting Works produce likewise a small quantity of alloys of nickel and copper, and of nickel, iron, and arsenic. The greatest producers of nickel in Germany, however, are the Saxon Cobalt Company of Oberschlema and Pfannenstiel, near Schneeberg, in the Saxon Erzgebirge.

Their annual production is over 10,000 lbs. of pure metal. The clay-slate and mica schist district, near Schneeberg, Lindenau, Zschorlau, and Neustadt, contains over 150 lodes, which yield nickel, cobalt, bismuth, and arsenic within a zone of 6 miles in length and about 2 miles in width. The mines and works date from 1,642, and employ at present over 1200 miners and smelters, and connected with them are the cobalt and nickel works of Modum in the south of Norway, from whence nickel and cobalt regulus are sent to Saxony for refining. The Saxon Cobalt Company exhibited very good samples of cubes and sheets of nickel.

Looking next to Austria, we found, in the Duchy of Salzburg, the Leogang Nickel and Cobalt Company, which produce ores of nickel, cobalt, and antimony from irregular metallic deposits in clay-slate. The ore is hand-picked, smelted in a blast furnace, and the regulus obtained is refined in a reverberatory furnace for a kind of white metal, or "speiss," containing 28 per cent. of nickel, 14 per cent. of cobalt, 6 to 8 per cent. of copper, and the rest iron, sulphur, and antimony. Flora von Flechner-Gersdorf, of Schladming, in Styria, likewise exhibited nickel ore, consisting of arsenide of nickel from the mines at Zinkwand and Vettern. The mica schist here contains strata, 2 to 8 fathoms thick, which are impregnated with pyrites and other metallic ores, and intersected by lodes which are metalliferous within these metallic zones or strata, and contain ores of cobalt, nickel, arsenic, fahlerz, and others.

From Hungary we found exhibits by the Kolba Metallic Mine Company, of Libthen, who produce annually about 300 tons of ores containing from 16 to 20 per cent. of nickel, 4 to 8 per cent. of cobalt, and some copper. The richest ores are sold to Evans, Atkins, and Co., of Birmingham, and the poorer stuff smelted for white metal before going to the market. The Zemberg Nickel Company, of Dobschau, in the north of Hungary, produce some 400 to 500 tons of nickel and cobalt ores at their mines Altenberg and Zinnberg. The strata of greywacke there enclose a large bunch of spathic iron ore, viz., carbonate of iron, which contains occasionally nickel and cobalt ores in contact with the enclosing rock. Underlying the iron ore are dioritic slates, which are traversed by numerous lodes and branch lodes, of which the Maria lode is the principal. They are composed of a black bituminous shale, which contains short, but rich, floors of nickel pyrites, together with fahlerz, arsenical pyrites, spathic iron ore, and ankerite. The richer class of ores contains about 17 per cent. of nickel and 5 per cent. of cobalt, and is sold in England.

In the Swedish department we found nickel ore, nickel copper, and metallic nickel, exhibited by G. Berg, from Warby and Westervik. The principal nickel works, however, are at Klefva, in Jönköping-Län, and at Sagmyra, in Kopparberg-Län, where magnetic iron pyrites is found in connexion with gabbro and serpentine in metamorphic gneiss. In 1871 their produce was 36,800 lbs. of nickel copper, and 673,000 lbs. of nickel regulus, with about 50 per cent. of nickel and cobalt, 30 per cent. of copper and 8 per cent. of iron. Almost the whole produce is sold to Berlin and Birmingham, where the metal is refined. In Norway there were in 1870, 10 nickel mines, which employed about 140 men, and yielded 88,000 cwt. of raw ore, consisting likewise of magnetic iron pyrites with 1·5 to 3, sometimes 5 to 7 per cent. of nickel. The largest works are at Skjaerdalen and Evje, in Ringerige in the south of Norway, belonging to the Ringerige Nickel Company, and at Bamble, near Kragerö on the south coast, belonging to Johan Dahll. From both works we found at Vienna very complete exhibits. The raw ore is first calcined in large heaps, and then smelted in a blast furnace with coke, in order to obtain a regulus with about 15 to 17 per cent. of nickel. This is again roasted in kilns, and smelted for a second regulus with about 30 to 35 per cent. of nickel, which is then remelted with coke in an open hearth under the oxidising influence of a strong blast, when nearly the whole of the iron and part of the sulphur are oxidised, and an alloy containing 50 to 60 per cent. of nickel, 25 to 30 per cent. of copper, and 24 to 26 per cent. of sulphur is obtained.

In the American section we found the very interesting exhibits of Josef Wharton, of Philadelphia, who showed nickel and cobalt ores including fine

samples of fibrous millerite, from Gapmine, in Pennsylvania, which seems to be a neighbour of the celebrated mine La Motte, and which contains a lode 5 ft. thick, yielding ores of nickel, cobalt, copper, and lead. There were also samples of nickel regulus and metallic nickel, alloys of half copper and half nickel, and metallic nickel in cubes, shot, and in plates, which latter are employed as electrodes in electro-plating. This process is largely carried out by the Keith Nickel Plating Company of New York, which employs the process of Professor Böttger, of Frankfort, who was the first to use a solution of sulphate or chloride of nickel-ammonium, from which the coating is deposited upon other metals by the action of a galvanic battery. South America, where rich ores of nickel are found in Peru and Brazil, exhibited nothing at Vienna.

Cobalt.

We have next to say a few words on the representation of cobalt, to which metal we have frequently alluded in our previous notes. Nickel and cobalt are, in fact, always so closely associated, that it will hardly be possible to find an ore of the one which does not contain at least traces of the other. The cobalt works, which produce oxide of cobalt and blue silicate of cobalt or "smalte," have had much to suffer from the manufacture of ultramarine blue, or artificial lapis lazuli; of late, however, they seem to have recovered, and their oxides find a profitable market as a fine blue paint for china and Wedgewood wares.

In the German section at Vienna we found samples of oxide of cobalt shown by Fleitmann and Witte of Iserlohn, the Victoria nickel works of Naumburg, in Silesia, and the Saxon Cobalt Company, of Schneeberg, which we have previously mentioned, and whose annual production of smalte and oxide is about 800,000 lbs., worth about 150,000*l*. Austria annually produces preparations of cobalt containing about 2,500 lbs. of metal at her nickel works in Salzburg and Styria, and Hungary, preparations containing about 50,000 lbs. of cobalt, at Dobschau, while the Kolba Metallic Mine Company, of Libthen, is also a producer of about 36,000 lbs. per annum of that metal. Cobalt ore was also exhibited from Dobsina, by Martin Sonntag.

The Swedish cobalt mines of Vena, in Nerike, and of Tunaberg, seem to be at a standstill, while the cobalt works of Skutterud and Modum, in Norway, which are the property of the Saxon Cobalt Company, have been started again with success. The ore is there cobalt-glance and arsenical cobalt pyrites, and is found more or less intimately mixed in a metalliferous band or zone of mica schist, varying from a few to over 100 fathoms in thickness, and dipping almost vertical. The ore is stamped and washed, carefully calcined in order to drive out its sulphur and arsenic, and then either smelted for blue smalte glass, or refined for black oxide. We have finally to notice again Josef Wharton, of Philadelphia, for his excellent exhibits of oxide, sulphate, and metallic cobalt, the latter being smelted in a furnace of particular construction, probably on the Deville system.

Mercury.

The exhibits of mercury were not numerous. In the department of Spain we met with a good mineral collection from the mines of Almaden, and of their metallurgical products by Francisco de Avila, of Madrid. The district of Almaden, near Ciudad Real, consists of the Silurian formation, containing hard sandstones with bituminous clay slates and beds of limestone and greywacke, with numerous fossils in its upper section. The bituminous slates or shales are traversed by three lodes, the known length of which is over 100 fathoms. Their width is on an average 21 ft., but in some instances increases to 40 ft. The two lodes, San Francisco and San Nicholas, approach each other to 3 ft. to 4 ft. for some distance, and are then worked together. The rock is rather weak, and the mines must be secured to a great extent by arches of stone or bricks, of which one, at a depth of 800 ft., has a span of 67·5 ft. The annual produce of these mines is equal to 32,000 bottles, or about 2,432,000 lbs. of mercury. The raw ore is mixed with carbonate of

lime, quartz, and clay slate, and is hand-picked into four classes, containing about 50, 30, 15, and 8 per cent. of metallic mercury. It is introduced in vertical kilns, closed on the top, and heated from underneath for 20 hours with brushwood, when the metallic mercury passes off through openings in the sides into condensing pipes, made of clay, and at last into condensing chambers. Each charge is finished after three days, when the mercury is collected, and drawn off from the condensing pipes. This operation was illustrated by models of the furnaces and samples of ore, mercury, and slags.

From Italy we found samples of mercury ore or cinnabar, shown by Dominicus Paradisi, from the mines of Siele, near Siena, and from those of Vallalta, near Agordo, in Lombardy. The latter ore is an intimate mixture of clay slate, porphyry, and bituminous clay containing from 1 to 60 per cent. of mercury, embedded in an irregular form in graphitic clay slate of the lower carboniferous period. The ore is heated in kilns with a wood fire, and the vapours of mercury are condensed and collected in wooden launders. The annual produce is about 35,000 lbs. by 136 men.

France also exhibited samples of cinnabar from Mimoun and Raaz-el-Maa, in the province of Constantine; and Austria, from Knapouse and Idria, in Carnolia, from which latter place, in 1872, 766,600 lbs. of mercury were produced.

The mines of Idria were discovered in 1497, and still give employment to 553 miners, and over 200 men at the dressing and smelting works. The principal ore deposit is again a black, bituminous, almost graphitic slate of the lower carboniferous formation, varying from 10 to 30 fathoms in thickness; it rests upon limestone, and is covered by a limestone conglomerate, bituminous shale and sandstone, the latter of Triassic age. The ore bed is explored for 400 fathoms in length, and 146 fathoms in depth, and in 1867 was estimated to hold nearly half a million hundredweight of mercury within 156,000 cubic fathoms of ore ground, the average being 2 per cent. The mines are opened by five shafts, with pumping and drawing machinery, driven by steam and water power. The ore is carefully hand-picked, and classified into rich ore, with 10 per cent., and into lumps and smalls, with 1·5 per cent. of quicksilver. The former is subjected to a distilling process from closed retorts, the latter to such an operation in kilns and in reverberatory furnaces, with admission of air. The metallic fumes are condensed in condensing pipes and chambers, and a great part of the metal is reconverted into cinnabar by amalgamating it with pure sulphur in rotating casks. The sulphide of mercury thus obtained is subjected to a process of sublimation, which yields crystalline cinnabar, with a beautiful vermillion colour, after being ground to a fine powder. The Idria works exhibited a collection of minerals, fossils, ores, and metallurgical products, including an iron basin containing 15,000 lbs. of quicksilver, and the mines and smelting works were also suitably illustrated by geological maps and drawings, showing the improvements that had been introduced of late years, principally for a better condensation of the fumes.

In the exhibition of Turkey we noticed a sample of cinnabar from the Vilajet of Janina, and in the collection of Professor Küstel a specimen of metacinobarite, from Redington Mine, in California, while the other great quicksilver mines of California, viz., New Almaden, New Tiria, Lake Mine, Guadalupe, and others, which produce about 3·5 millions of pounds annually, were entirely unrepresented, and the once celebrated mine of Santa Barbara, at Huancavelica, in Peru, which formerly yielded the greater part of the mercury which was used in amalgamating silver ores in South America and Mexico, appears to be quite abandoned since the discovery of the mines in Upper California. There is no doubt that this discovery was a cause of paramount importance for the rapidly increasing production of precious metals, and the consequent colonisation of the west coast of America.

Bismuth.

Bismuth is the next metal we have to mention; very little of it, however, was to be seen at the Exhibition. This metal, which is an essential part of the alloy used in stereotyping woodcuts, and the oxide of which is largely em

ployed as a lustre paint with painted chinaware, and as a white paint for ladies' toilettes, is principally produced in the Saxon Erzgebirge, and in Peru, where it is found in its native state, or in combination with sulphur and copper, together with ores of nickel and cobalt. The Saxon Cobalt Company, of Oberschlema and Pfannenstiel, near Schneeberg, produce annually about 24,000 lbs. of bismuth, of which beautifully-crystallised samples were exhibited. The Zwitterstock Tin Company also produce about 1,000 lb., and the works at Johanngeor Neustadt, Altenberg, and Freiberg about 8,000 lbs. annually. At the latter place the metal is found concentrated in the bottom, or hearth, of the silver expelling and refining furnaces, from which it is extracted by means of hydrochloric acid. From that solution basic chloride is precipitated, and reduced to metal by being smelted in crucibles with soda, charcoal, and a glass flux. In this way about 5,000 lbs. are annually obtained. At the other works the metal is produced in inclined iron retorts, wherein the ore, mixed with charcoal, is heated, and the metal, which, from its great fusibility, easily sweats out of the rock, is collected at the lower part, and tapped off. At Joachimsthal, in Northern Bohemia, bismuth ores are also found—together with silver, lead, cobalt, and uranium ores—upon lodes which intersect strata of metamorphic mica schist, limestone, and quartz porphyry. The mines have reached to a depth of 283 fathoms, and employ 380 men, who produce annually about 11,000 cwt. of dressed ores, among which are 358 cwt. of bismuth ores, which yield about 5,000 lbs. of metal. The uranium ore, or uranite, is prepared for commerce at the works of Joachimsthal, and from about 154 cwt. of dressed ore, 8,000 lbs. of uranium preparations, for paint upon chinaware and for the colouring of glass, are produced. They are sold at the following prices per pound, viz., light uranium yellow and orange at 24*s*., hydrate of oxide of uranium and high red uranium oxide natron at 28*s*., uranium protoxide at 36*s*., and uranium oxide kali at 33*s*. The metallic bismuth of commerce is never quite pure, and generally only contains from 94 to 97 per cent., while the rest is copper, sulphur, antimony, and arsenic.

Antimony.

We propose next to give a rapid review of the exhibits of antimony, which metal finds a large employment in various useful alloys. Thus printers' metal contains 17 to 20 per cent., Britannia metal 10 per cent., pewter metal 7 per cent., métal argentin 14·5 per cent., Asberry metal 20 per cent., and so on. The latter alloy is largely used for bearings in steam engines, railway carriages, rolling mills, &c. At Vienna, in the sections belonging to our colonies we noticed grey antimony ore from the Costerfield Gold and Antimony Company, and from Oven's Gold and Tin Company, both of Victoria. In Portugal were samples of such ore exhibited by José Ferreira Castello, from Montemoro Novo; by Antonio Henrique, from Gondomar, and by Saares Sobrino and Socios, from Alcontrin. Spain showed samples of the ore, of crude antimony and metallic antimony (*antimonium regulus*), by the Distrito Minero de Ciudad Real, by the Union de Capiliera Rodriguez Hernandez, of Zamora José Maneja y Fabrigos, of Barcelona, and José Comas, from Torevella de Monta, near Gerona. France showed likewise a few samples of grey antimony ore from Hamminiat-Arco, and from the mine Taya in the Department of Constantine, and white antimony ore or sénarmontite from the mines of Soussa in the same province. The best exhibits of this metal, however, came from the Austro-Hungarian empire. The Milleschau Antimony Company, of Bohemia, owns some considerable mines at Milleschau, near Mirowitz, not far from the Moldau river. They are driven upon seven lodes in granite, from 1 in. to 2 fathoms thick, and composed of decomposed granite and clay, with impregnations and solid floors of antimony ore, which reach 5 ft. in thickness. There was a solid lump of grey antimony exhibited, weighing 2,300 lbs., besides beautiful samples of crude antimony or sulphide of antimony, metallic regulus antimony, crystallised in beautiful stars, oxide of antimony, and glass of antimony. The works employ about 300 men. There was also ore shown by Miesler and Zboril from the mines Cölestin and Segen Gottes, at Pamau, near Plan, in Bohemia. It comes from lodes, 2 fathoms wide,

intersecting the mica schist of that district. Hungary, which in 1871 produced 2,533 cwt. of antimony, owns also some very important mines. From those of Berzete, in the Ramzas mountains, near Rosenau, in Northern Hungary, Livius Madersbach exhibited excellent specimens of grey antimony ore as well as of crude antimony. Ignaz Fritsche showed ore, crude and metallic antimony from the Obermetzenseifen Antimony Works, near Schmöllnitz; Samuel Diener and Son, metallic antimony from Lipto Szt. Miklos, and Julius Schnabel, antimony ore from Oravicza in the Banate. At the works of Obermetsenseifen in the valley of Goldseifen, the metal is produced in reverberatory furnaces, and refined by remelting with oxidising fluxes.

Arsenic.

Next we may mention here a few exhibits of arsenic, sent by the Reiche Trost Company, of Reichenstein, in Silesia, by the Freiberg Smelting Works, which produce annually 16,000 cwt. of arsenical preparations, and by the Rothgulden Company, of St. Michael, in Salzburg. The preparations consist of white arsenic, arsenic glass, orpiment or yellow arsenic, and realgar or red arsenic, the former being oxides, the two latter sulphides of arsenic. The ore from which the arsenic is derived is generally arsenical pyrites, which in the instance of Reichenstein is auriferous.

Zinc.

Though Great Britain is a producer of over 5,000 tons of zinc or spelter annually, obtained partly from blende or sulphide of zinc ores, derived from the mines of Cornwall, North Wales, and the Isle of Man, and partly from calamine or carbonate of zinc, for the greater part imported from Spain, Sardinia, and Algiers, we could not detect at Vienna a single exhibit of this metal, either from the mother country or the colonies, with the sole exception of a specimen of yellow blende from the Perseverance Mine, Collingwood, Nelson, in New Zealand, which was almost pure sulphide of zinc, with 60 per cent. of metal. It is to be regretted that the spelter works of South and North Wales, and the North of England were entirely unrepresented. The total production of spelter or raw zinc in Europe is estimated at about 113,000 tons per annum, of which quantity there are made in Prussia, 58,200; Belgium, 40,000; England 5,000; Russia, 3,300; France, 3,000; Austria, 2,200; Spain, 1,600; and Saxony, 100 tons. The quantity of spelter made in the United States, particularly in the States of New Jersey, New York, New Hampshire, and Pennsylvania may be computed at about 4,000 tons annually; however it has been greatly on the increase of late years. France showed some samples of zinc ore from her Mediterranean colony, namely, from the mines of l'Ouarensenis, in Algiers, and brown blende from those of Kef, at Oum-Theboul, in Constantine.

Spain, which is very rich in zinc, but only manufactures it to an insignificant extent, made a good show of zinc ores. Since the important deposits of calamine and silico-calamine were discovered in 1852 by the late Adolphe Lessoine, professor of metallurgy at Liége, the working and mining of these minerals has made enormous strides. The Cantabrian Mountains, which stretch from the Pyrenees westward through the provinces of Guipuscoa, Santander, and Asturias are chiefly composed of rocks which belong to the cretacean period, and the lower parts of which consist of alternations of sandstone and limestone, above which follows a thick bed of argillaceous limestone, and on its top a considerable thickness of dolomite, both, however, separated by a distinct bed of clay, which is richly impregnated with hydrate of iron, ochre, and limonite. This bed forms, to a very great distance, the underlying stratum of numerous metallic deposits within the dolomite. These ore deposits have generally a very irregular shape, being partly beds and pockets, but sometimes they assume the character of lodes, which penetrate upwards through the rugged and corroded dolomite. The ores are blende, calamine, silico-calamine, willemite, and oxide of zinc, together with lead

ore, iron ore, and pyrites. At the Fortuna Mine lead ore is predominant, this having been raised in the times of the Romans, as clay lamps of Roman origin, found in the mine, testify. The mines Nuestra Sennora de las Nieves and Augustina, near Nestosa, produce principally calamine in beds and lodes, the purest ore being silico-calamine, with 66·25 per cent. oxide of zinc, 23·74 silica, 8·31 water, and 1·08 alumina, but also carbonates and oxides. A curious mineral, carranzite, is also found here, containing 28·45 per cent. oxide of zinc, 20·27 alumina, 31·51 silica, and 19·65 water; it resembles soapstone, and when fresh broken is white, but, exposed to the air, it soon becomes brown and black. The ores of Cumillas are similar, but contain more blende, and sometimes much galena; samples were exhibited by Perez dal Molino, of Santander, and Bernier and Co., of Cumillas, being both blende and calamine. Fine samples of calamine were shown at Vienna by the Compania Asturiana, of Torre la Vega, and from Tolosa, near Guipuscoa. The South of Spain showed exhibits from Badajoz and Carthagena. Spain raised in 1869 113,500 tons of zinc ore, of which by far the greater part was exported to England, Belgium, and Rhenish Prussia.

In the department of Italy we met with samples of blende from Parre, near Bergamo, in Lombardy; but the greatest deposits of zinc ore are to be found in Sardinia, in the neighbourhood of Iglesias. To Minister Sella, formerly Sardinian mining engineer, we owe a very good geological map of this island, from which it appears that the zinc deposits of Sardinia belong to the silurian limestone and dolomite, and that they are of equal age with the lead ore beds of Sardinia, mentioned in the former article. We noticed samples of calamine and blende from Iglesias, exhibited by the Montefidano and Monteponi Companies, by the Compagnie des bons Amis, Messrs. Henfrey, Etchats, and Co., the Gonnesa and Vieille Montagne Companies, and others; and calamine by the Sardinian Company for the mines of Finy and Nebideddo. The ores contain generally some lime and lead, and some of them fluorspar, and then they require an attentive treatment in the furnaces. There is hardly any metallic zinc yet made in Sardinia, nearly all the ores being shipped to England and the Continent.

From Sweden we found shown at Vienna very fine specimens of brown blende in the collection of the Vieille Montagne Company, derived from their mines at Ammeberg, near Oscarsund. The metamorphic gneiss contains here large beds of blende, partly well mixed with the rock, so that it must be separated by stamping and washing. These mines produced, in 1871, as much as 32,000 tons of ore, and the value of the estate is booked at about 160,000*l*., the outlay for it having once attained the respectable sum of 360,000*l*. Norway produces also ore of zinc blende, near Drammen, at the Jarlsberg mines, and exports about 3,000 tons of washed ores to England; of these ores we found a very complete collection exhibited, showing the products of the self-acting jigging machines, and of the Rittinger side-blow tables, which are employed for the dressing of the ores after being crushed in Blake's stone breaker, and Carr's disintegrator, and classified in rotating sieve classifiers, and in Rittinger inverted pyramidal classifiers or "Spitzkasten."

In the Belgian section we noticed amongst the exhibits of the Bleyberg-és-Montzen Company, good specimens of blende, and the mines of Bleyberg and Schimper yielded in 1872 not less than 4,500 tons of that mineral. Near Montzen, close to the Prussian frontier, the mountain limestone contains a considerable lode running north and south, which in its northern part yields principally galena, and is found metalliferous to a depth of over 77 fathoms, while towards the south in the Renaissance mine, the lode contains more zinc ore, and is followed here down to a depth of 90 fathoms. Besides this lode the company drives workings upon a so-called contact-deposit, which is found between the mountain limestone and the underlying rocks of the Upper Devonian or Verneulli slate, and seems to be the continuation of the lode. This bed or bunch of ores contains both galena and blende, and is explored to a depth of over 70 fathoms, and at the Schimper mine, over 250 fathoms in length, with rich ore ground. The mines are drained by steam and water power. The ores raised are hand picked, and dressed in a mill, which is pro-

vided with the most approved modern ore dressing machinery. They are then ground to a fine powder, carefully roasted in large calciners, in order to drive out the sulphur, and to prevent the formation of sulphates, and reduced in retorts into metal, of which 940 tons were obtained in 1872, together with 2,031 tons of lead, and 880 lbs. of silver.

The next neighbour of these works is the celebrated Altenberg or Vieille Montagne Zinc Company, which owns very extensive works both in Belgium and Germany, and which exhibited its products at Vienna in a separate pavilion in front of the great building. This company was started as a share-holding concern in 1837 by the acquisition of the mines of the Altenberg of Moresnet, near Aachen, from the heirs of a Mr. Mosselman, and through careful mercantile management and excellent technical superintendence, for which the company is indebted to its chief mining engineer, Bergrath Max Braun, it has attained its present prosperous state and wealth. Originally started with a capital of 36,000*l.*, the company has twice issued preference shares of 400,000*l.*, and owns now property in Germany, Belgium, France, Sweden, and Italy, which is valued at nearly one million pounds sterling. The progressive production of spelter will best illustrate the rapid advance of the company; it was in

	Tons.
1837 - - - - -	1,833
1840 - - - - -	3,631
1850 - - - - -	9,180
1860 - - - - -	28,925
1870 - - - - -	42,112
1871 - - - - -	41,129

and from the raw zinc or spelter were produced in the last-named years 6,851 tons of zinc white, and 27,462 tons of sheets of zinc, the total number of workmen employed being 6,928, who supported families numbering 20,600 persons. The total production of spelter in 1872 was somewhat less, being only 39,663 tons.

The mineral deposit of the Altenberg belongs likewise to the mountain limestone, and has a length of 208 fathoms; in its upper part it is separated by a wedge of dolomite into two portions, of which that towards the north-east is 45 fathoms thick, and at its present depth of 18 fathoms nearly exhausted, after having yielded by open cast working above one million tons of ore. The south-western portion is covered with a bed of clay and dolomite, and at 33 fathoms from surface it is 100 fathoms long, and from 10 to 20 fathoms wide, while its continuation towards south-west, and in depth, is not yet explored. The ore consists of a mixture of carbonate of zinc or calamine and hydro-silicate of zinc, or silico-calamine, besides some willemite, or silicate of zinc. The absence of blende, galena, and pyrites is rather remarkable. The calcined zinc ore contains from 35 to 68 per cent. of oxide of zinc with traces of cadmium, 20 to 34 per cent. of silica, 2·5 to 14·5 per cent. of alumina, 6 to 13 per cent. of oxide of iron, besides small quantities of magnesia, lime, and manganese, or from 30 to 55 per cent of metallic zinc.

The Vieille Montagne Company owns further mines at Welkenraedt and Flône-sur-Meuse, in Belgium, five important zinc and lead mines at Bensberg, near Cologne, others on the Moselle, at Wiesloch, in Baden, and the Ammeberg mines in Sweden, noticed above. Of late it has also acquired important mines in Algiers, and at St. Louis, near Cagliari, in Sardinia. In 1871, the works of the Company smelted 63,200 tons of ore from their own mines, and 46,200 tons bought from foreign mines, or altogether 109,400 tons, which yielded 41,129 tons of spelter. The smelting works are situated at St. Léonard, Angleur, and Valentin-Cocq, near Liége, in Belgium, at Moresnet, Mühlheim, and Borbek, in Germany, and at Viviez and Penchot, in the centre of France; the latter works being only recently erected, and intended to produce about 5,000 tons of raw zinc from Sardinian, Spanish, and Algerian ores.

Besides these smelting works the Vieille Montagne owns establishments for making zinc white at Bray and Asnières, in France, Valentin-Cocq, and

Mulheim, and rolling mills for sheets, at Oberhausen, in Germany, Tilff, in Belgium, and Bray and St. Marie in France. The total engine power at the company's mines and works reaches the respectable figure of 2,400 horse-power.

The ores which are smelted consist of about equal parts of calamine and blende; the latter requires a very careful calcination, in order to convert it into oxide, and to free it from sulphur. Formerly this was done solely in long reverberatory calciners through manual labour, and with a considerable amount of fuel, while all the vapours of sulphur went off without being utilised. For five or six years past, however, the first calcination has been performed in vertical Gerstenhoefer kilns, which require, when once heated, no more fuel, as the burning sulphur will supply the heat which is required; but as the ore cannot be entirely freed from sulphur in this way, the charge must be finished in ordinary calciners. The sulphurous acid from the Gerstenhoefer kilns is condensed in sulphuric acid chambers. The oxides of zinc obtained by the calcination of calamine and blende are reduced to metal by being heated in closed vessels with carbonaceous matter, when the metal distils off, and is collected in condensers.

There are two systems of furnaces in operation. Of these, one is the Belgian furnace, or "four de Liége," which contains a great number of tubular fireclay retorts, filled with the mixture, these being heated by an ascending flame; while the other is the Silesian furnace, which is rather more like a reverberatory furnace, and contains Ω-shaped retorts or muffles disposed in two rows. The economical progress of this distilling process in late years is rather remarkable. The Belgian furnaces used to contain only 30 tubular retorts, and to reduce 4 cwt. of ore in a day, while they now contain 70 tubes, and smelt 24 cwt. in 24 hours. In the Silesian furnaces the number of the retorts has been increased from 20 to 30, and even 40, and the quantity of ore which they can reduce has been augmented from 8 to 30, and 40 cwt. daily. Through the introduction of improved fire-grates, fan-blast, and gas generators, a great saving of fuel has also been effected, and the loss of metal, which formerly was about 40 per cent., has now been reduced to the still very high figure of 20 to 25 per cent. of that contained in the ore.

We now proceed to notice the other zinc works of Germany. At Vienna we met with exhibits from the Stolberg Lead and Zinc Company, which, at their mines of Diepenlinchen, near Stolberg, Mühlenbach, near Coblenz, and Ramsbek, in Westphalia, produce about 13,600 tons of blende, which is smelted at the spelter works of Stolberg and Dortmund, together with calamine, derived from the company's mines of Grugua, in Sardinia, into about 7,600 tons of raw zinc, of which 1,800 tons are rolled into sheets. The works of the company contain 28 blende calciners, 4 calamine kilns, and 78 Silesian muffle furnaces, part of these being provided with Siemens' regenerative heating arrangement. The same system has been introduced, since 1862, at the Wilhelm works of the Rhenish-Nassau Mining and Smelting Company, of Eschweiler, near Aachen.

The ore comes from the mines at Stolberg, Bensberg, Wiesloch, in Baden, Motevecchio, in Sardinia, Gar Rouban, in Algiers, and the annual production of the Silesian furnaces is 3,900 tons of spelter. The rolling mill of Wilhelm Grillo, at Oberhausen, in Rhineland, exhibited very good samples of zinc sheets and zinc white, of which about 2,500 and 1,200 tons respectively are made there annually by 100 men.

We may also mention here the Berzelius spelter works of the Bensberg-Gladbach Zinc Company, near Cologne, which produced, in 1872, 2,800 tons of spelter. Here a new system of reducing zinc ore in blast furnaces has been tried not unsuccessfully. Again the Mark-Westphalian Mining Company, of Grüne and Lethmate, in Westphalia, which have introduced Daehne's improved Belgian furnace, which, by its honeycomb arrangement of the front, allows about 40 per cent. more tubes to be placed in an equal area, and which is heated with small coal dust that is fed through openings in the roof and consumed, while it falls down between the retorts, so that only ashes arrive upon the bottom of the furnace. The ordinary furnaces are of the Belgian

type, and the produce of the works at Grüne and Lethemate is 3,000 tons of metal per annum. The ores, which are smelted here, occur in the Devonian limestone in contact with the underlying slate, and form irregular beds or bunches, but extend over a zone nearly 12 miles in length, between Grüne, Iserlohn, and Deilinghofen. The bed of zinc ore is 44 fathoms long and 14 fathoms thick at Iserlohn, 52 by 11 at Calle, 21 by 3 at Westig, and it sends many branches or veins into the dolomitic limestone to a distance of 30 fathoms. The ore is calamine and silico-calamine, but it changes into blende with increasing depth. The zinc works of Freiberg in Saxony smelt the blende from the mines of that neighbourhood, and are of little importance.

We shall conclude our review of German zinc exhibits by noticing Upper Silesia, where, in 1872, 24 smelting works, containing 509 furnaces with 12,948 muffles or retorts, produced not less than 32,500 tons of zinc from 290,000 tons of calamine, and with a consumption of 50,000 tons of coal, or 1 ton from 9 tons of calamine and 15 tons of coal. This result is owing to the ever-increasing poorness of the ore, which in 1853 still yielded 20 per cent. of metal. The zinc ore of Upper Silesia, as well as of the adjoining Russian province of Poland, belongs to the Triassic limestone or muschelkalk, and is bound to a certain level between the bottom limestone and the overlying dolomite, which covers a considerable area around the towns of Beuthen and Tarnowitz. There are generally two beds or layers of calamine; the lower, called the white bed, rests immediately upon the bottom limestone, and consists of small seams and nodules of calamine, embedded in a sandy clay and rotten limestone. It is generally a few feet, sometimes, however, over two fathoms thick, and when pure yields 20 to 30 per cent. of zinc. The red bed is separated from the former by a stratum of clay, and composed of hydrate of iron or of dolomite, and reaches sometimes, as at Scharley mine, the considerable thickness of 8·5 fathoms. It generally fills hollows and basins of the bottom limestone, and at some places, as at Great Dombrowka, Scharley, and Meichowitz, the lower strata of the dolomite enclose a bed of blende over 1·5 fathoms thick, and covered by dolomite containing zinc. The richest bed was at Scharley, and is almost exhausted, the yield of the ore having since 1820, fallen off from 30 to about 12 per cent. of zinc; the beds of blende, however, seem to secure the existence of the spelter works for a considerable time to come. The red bed contains frequently galena, and this ore caused the first mines to be opened at Beuthen, Scharley, and Dombrowka as long ago as in the thirteenth century; but in consequence of quarrels between the miners and the clergy, they came to a stop in the middle of the fourteenth century, and were only re-opened in 1526 by the Duke of Oppeln. In 1542, the first horse whim was put up here by Hungarian miners, and calamine has been exported in a calcined state since 1560 to Brandenburg, Holstein, and Sweden for the manufacture of brass. The Thirty Years' War interrupted the mining operations a second time, and they were only taken up again in 1660, and since Silesia had become a dominion of Prussia, slowly increased their production to 900 tons of calamine in 1792.

The production of metallic zinc is of a rather recent date, although the Benedictine monk, Basilius Valentinus, of Erfurt, in Thuringia, had discovered the metal at the end of the fifteenth century. It seems, however, to have been made in England since the middle of the eighteenth century, where John Christian Ruberg, a native of Ilsenburg, on the Harz, saw the process about the end of the latter century, probably at Bristol. He tried to introduce the distillation of zinc in Germany, and in 1798 he succeeded at last in a furnace built at Wesolla after the pattern of a glass furnace. Subsequently the manufacture of the metal began gradually to increase. The second spelter works were erected in 1809, and the metallurgist, Freytag, constructed at the Lydognia Works, from 1810 to 1817, several furnaces after different plans. In 1820 there were only two mines in existence, while in 1825 already 24 mines were in operation to provide 27 spelter works, with about 50,000 tons of calamine. This over production caused a serious fall of the price, which in 1830 reached as low as 7*s.* the hundredweight, and caused the stoppage of most of the works and mines.

The gradual technical development of the zinc metallurgy in Silesia was at the Vienna Exhibition very well illustrated by Gustav Schneider, of Kattowitz, by means of numerous drawings and models of furnace made to scale, representing the Ruberg furnace, of 1798, the Freytag furnace of 1816, the Knaut furnace of 1833, with 20 muffles and ore calciner. Chimneys have been introduced to increase the draught of the furnaces since 1854, and gaseous fuel was used in 1849 by Menzel, and 1855 by Klemann and others, while in 1863 the Siemens regenerators were introduced at Antonienhütte. On the very interesting metallurgical history of this district, the "Zeitschrift für Gewerbe, &c." published by Dr. Adolf Frantz, of Beuthen, 1873, No. 7, contains some more details, for which we cannot afford space in our present review. Amongst the exhibits from this district we noticed samples of calamine, silico-calamine, and blende from the mines Scharley, Rudolf, Paul Richard, Minerva, and Bley-Scharley, by George von Giesche's heirs, of calamine from New Helen, by the Duke of Ujest, from Maria, by Von Tiele-Winkler, from Elisabeth, by Countess Schaffgötsch, and from Samuelsglück, by Director Grützner; while spelter or raw zinc was exhibited from Lydogniahütte, by the United Königs and Laurahütte Company, and from the spelter works, August, Theresia and Norma (which have existed at Hohenlohütte since 1825) by the Duke of Ujest. Von Ruffer, of Breslau, made a very good show of zinc sheets from his rolling mills at Piela, where about 1,650 tons of different sizes are produced annually. We will conclude our notice on the zinc industry of Upper Silesia with a few statistical data, which will show the increasing produce of the metal, and the decreasing yield of the ore :—

Year.	Ore.	Zinc.	Yield.
	Tons,	Tons.	Per cent.
1812	678	184	27·22
1817	1,488	408	27·50
1823	30,300	6,370	21·04
1853	140,565	28,113	20·01
1858	290,770	37,340	17·80
1863	251,343	39,282	15·63
1868	315,480	37,560	11·90
1870	315,682	36,444	11·54
1872	289,992	32,526	11·22

We have now to say a few words about the zinc exhibits of Austria, amongst which we remarked particularly those of Count Adam Potocki, of Chrzanow, in the grand duchy of Krakau. The triassic limestone and dolomite of Silesia continue in that duchy with numerous metallic deposits, which also gave rise to mining at an early period, near Olkusz, Psary, Kati, and Chrzanow. The mines of Count Potocki, at Lgota and Ostreznica, yielded, in 1871, over 6,000 tons of calamine, by 523 men, and the ore was reduced at the works of Siersza, in 14 Silesian furnaces, and gave 770 tons of spelter, or a yield of 18 per cent. There are two other zinc mining companies in the neighbourhood, that of Von Tiele-Winkler, at Chrzanow and Trzebinia, and the Dlugoszyn Company, near Szakowa, close to the frontier of Prussia. Count Potocki exhibited also a model of a gas zinc furnace, besides ores and products. Count Henkel von Donnersmark showed fine specimens of zinc sheets from his rolling mill at Priwos, near Moravian-Ostrau, in Moravia, some of these weighing 2,200 lbs., while others were quite thin. There were also rods for wire making of superior quality.

There are also a few zinc mines in the Alps. The Bleiberg Company, of Villach, in Carinthia, mentioned in the division on lead, produced in 1871 about 2,500 tons of blende and 550 tons of calamine, while the mines of the Government and of Struggl's heirs at Raibl yielded 618 tons of the former,

and 670 tons of the latter. Calamine, which yielded over 35 to 40 per cent., was likewise raised at the mines of Jauken, in Carinthia, to the extent of 490 tons, while Johannesthal, in Styria, yielded 350, and Silberleiten, in Tyrol, 300 tons, which were reduced to metal at the spelter works of Johannesthal and Sagor, and gave about 850 tons of spelter. Raw zinc was also shown by Theodor Aichelberg, of Saint Stefan, on the Gail, in Carinthia.

Hungary owns only the zinc works of Ivanec, near Agram, in Croatia, which, from their own and purchased ores, produced about 415 tons of spelter in 1871. The exhibits of the Ivanec Mining and Zinc Company consisted of ores, stalactitic, and remelted zinc in ingots. The zinc formation of Upper Silesia extends also into Russian Poland, and George von Kramsta works calamine mines near Radom and Boleslaw, from which, at the spelter works of Romani and Paulina, 1,326 tons of metal were made, while the government mining administration of Poland makes 1,600 tons of zinc at Piotrekow, from similar ores raised at Dombrowa. The samples and explanatory drawings which were shown were rather interesting.

North America exhibited at Vienna a few specimens by H. T. Blow, of St. Louis, namely, silico-calamine from Granby, and blende from Minnesota. while Josef Wharton, of Philadelphia, showed zinc produced from very clean ores made in ordinary zinc-reducing furnaces, and said to be chemically pure. Lastly, the interesting mineral collection of Professor Küstel included a remarkable piece of reddish brown blende, which contains so much sulphur that the latter sweats out of it when simply heated before a fire.

Cadmium.

We have now to notice a few exhibits of cadmium, a metal which resembles zinc in many respects, and is always associated with it. It was discovered in 1817 by Stromeyer and Herman, is white like tin, malleable, and can be distilled like zinc. Many of the new alloys, which have a great fusibility, contain cadmium; such is the case with Wood's metal, which contains 3 parts of cadmium, 4 tin, 15 bismuth, and 8 lead, and melts at so low a temperature as 70 deg. Cels. or 158 deg. Fahr., while the Hofer metal, which is used for clichès, is composed of 22·5 cadmium, 36 tin, and 50 lead. The sulphide of cadmium makes a beautiful yellow paint, "Jaune brilliant," and is also employed by pyrotechnists to produce blue coloured light. At the exhibition we noticed a sample of blende containing cadmium from Ben-Athin, in Algiers, exhibited by Alphonse Bodart, of Lovegnée, near Huy, in Belgium. The annual production of that country is about 600 lbs. of cadmium at Engis, made, however, from Spanish zinc ore. The calamine of Wiesloch, in Baden, holds 2 per cent., that of Upper Silesia sometimes 5 per cent. of cadmium, while blende from the Harz was found to contain 0·5 to 0·7 per cent., from Przibram, in Bohemia, 1·78 per cent., and from Eaton, in the United States, 3·2 per cent. of cadmium. When a fresh charge of zinc ore is sufficiently heated in the retorts to begin giving off its metallic fumes, brown vapours of cadmium are seen to come forth, and to be condensed with oxide of zinc in the clay receivers. This product is collected and distilled anew, when pure cadmium may be obtained. In Upper Silesia 2,839 lbs. of cadmium were made in 1872, and Count Adam Potocki, of Chrzanow, exhibited a block, weighing 300 lbs. The price is about 5*s.* the pound.

Tin.

We conclude this section by noticing the exhibits of tin ore and tin. In the department of Great Britain we met with a collection of Cornish minerals, by W. Broad, of Falmouth, and amongst these specimens we noticed samples of tin ore and metallic tin from South Carn Brea mine, in Cornwall. It is to be regretted that this duchy, which in 1871 made from 16,500 tons of tin ore over 11,000 tons of metal, was not better represented, as it is the greatest producer in Europe. In our colonies we found a sample of tinstone, peroxide of tin, exhibited by C. H. Davonport, of Ballanden, in Queensland, as the sole representative of our considerable Australian tin production, which

has reached the respectable figure of about 4,000 tons per annum. In the Indian Department we noticed a sample of metallic tin from Karen Hills, east of Tongoah, in Burmah, which was cast in a bamboo, and other samples from the north part of Malacca, where a considerable quantity of metal is produced from stream tin. This owes its origin to a stanniferous granite which is easily decomposed by atmospheric action, and from which the tropical torrents of rain wash away the earthy matter, leaving the heavy tin ore behind. Also in the Exhibition of Holland we met with a block of tin from Billiton, in the Dutch colonies of India, as a single specimen of the extensive tin trade which is entirely in the hands of the Dutch Commercial Company, of Amsterdam, and from the islands of Billiton and Banca, furnishes about 9,000 tons of metal annually. The Government's collection of Siamese products also showed a sample of tin. Turning again to Europe, we have to mention in Portugal a rich collection of tin ores and tin by the Companhia de Mineracion de San Pedro do Sul, by the Perseverance Mining Company, of Vallongo, and by Santos and Sauzos, of Braganza. Spain is only beginning, and in 1869 produced 476 tons of tin ore, samples of which, together with metal, were exhibited from Zamora by Francisco Domingo, of Carbajosa, and from Salamanca, by the Associacione Mineraria, Jose Secalle, Ramon Otero, of Estrade, and from San Tome de Rezados, near Salamanca.

In Germany we met with a few tin exhibits by the Zwitterstock Factorei of Altenberg, in the Saxon Erzgebirge. Here a stanniferous zone of granite extends over a distance of 100 miles, and 10 to 20 miles wide, containing tin ore, either in the shape of bunches or stockwerks, in connexion with porphyry, or in the form of lodes of which about 380 are so far known to exist in granite, porphyritic syenite, gneiss, and slates. These lodes, varying in thickness from one inch to one fathom, are mostly found in the western part of the zone near Geising, Marienberg, Johangeorgenstadt, and Eibenstock, always containing tin ore, together with wolfram, apatite, fluorspar, topaze, &c., while the porphyritic stockwerks are found more east in the neighbourhood of Altenberg. Tin mining here dates from 1458, and the Zwitterstock Company produces about 100 tons of tin annually by employing 400 men and 1,200 stamp-heads, 60 percussion tables, and two smelting furnaces. The tin ore is, in fact, nothing but a stanniferous porphyry containing seldom over 0·5 per cent. of metal. It is therefore burnt in large heaps, in order to make it brittle, and then stamped and washed until it gives a metallic slime, with 60 per cent. of metal, which goes to the smelting works. The total production of Saxony does not reach 200 tons of tin per annum. This stanniferous zone extends also into Bohemia, where tin mining is carried on at Zinnwald, Graupen, and Schlaggenwald. At Zinnwald are nine peculiar lodes, which are called seams, somewhat of the shape of spherical segments, one over the other, in a white granite, varying in thickness from an inch to 4 ft. They contain tin ore, wolfram, bismuth, fluorspar, and many other minerals, but their produce is at present quite insignificant. The tin works of Ober Graupen, near Teplitz, have of late been taken again in hand, although they are older than the Saxon tin mines, and date from the 12th century. The ore is found in lodes, which intersect the gneiss, mostly intimately mixed with quartz, so that the raw ore contains hardly from 3 to 4 per cent. of metal. It is therefore burnt, stamped, and washed until a rich slime is obtained, which has hitherto been smelted in blast furnaces, but it is intended to introduce the English method of tin smelting in a reverberatory furnace. The company made a very good show of their ores, tin, and alloys of tin and bismuth, which are used for bearings in axle-boxes, rolling mills, &c. Russia produced, in 1870, about 1700 tons of tin ore, mostly stream tin from Siberia; and Turkey also showed a few specimens of tin stone from the vilajet Castamuni, in Asia Minor, and from that of Edirne, or Adrianopel, in Rumelia. In both instances the ore seems to be connected with lodes in granite.

LOCOMOTIVES.

It is a matter for regret that in such a collection of locomotives as that shown at the Vienna Exhibition, the makers of Great Britain, France, and the United States were not fairly represented. Altogether there were 47 locomotives in the Exhibition; but of these Great Britain supplied only two, France but three, and the United States none at all. Germany and Austria were both large exhibitors, and Belgium was fairly represented by its leading firms; but we missed the names of those makers who have gained England its reputation for locomotive engineering, and we cannot but regret that examples illustrating the widely different practice of our Transatlantic friends did not occupy their proper places at Vienna. Even with these deficiencies, however, the collection of locomotives at Vienna was a most interesting one, and one which well repaid careful examination, but it was as we have stated a matter for earnest regret that it should have been almost limited to the productions of two or three Continental nations, instead of embracing the results of a wider range of practice.

In order to give a good general idea of the locomotives exhibited at Vienna we have prepared, to accompany the present report, the Table contained in the Atlas of Plates (see Plate CXXVI.), this Table stating the class of each engine, the number and sizes of wheels, and length of wheel base, the position and size of cylinders, the heating surfaces, the weight, and other leading particulars. It will be noticed that one of the columns of the Table is headed "length of rigid wheel base." This column has been introduced because there are several engines which are fitted with bogies, or in which lateral play is allowed to one of the end axles for the purpose of giving a moderate amount of flexibility.

United Kingdom.

Tank Locomotive by Henry Hughes and Co.—Commencing at the western end of the Machinery Hall, we found, as we have said, the American department without any locomotives whatever, and but two in the British section. The first of these latter was a small four-wheeled outside cylinder tank engine by Messrs. H. Hughes & Co., of Loughborough, requiring no special notice. The engine is of the ordinary pattern constructed by the makers, all the wheels being coupled and the water being carried in a saddle tank; the principal dimensions are as follows:—Cylinders 8½ in. in diameter, 1 ft. 3 in. stroke; wheels 2 ft. 6 in. diameter; wheel base 4 ft. 6 in.; total heating surface 233 square ft.; firegrate area 5 square ft.; weight 8 tons empty, and 10 tons loaded. The engine is for the ordinary 4 ft. 8½ in. gauge.

Tank Locomotive by Fox, Walker, and Co.—The second locomotive in the British section was an outside cylinder six-wheeled tank engine by Messrs. Fox, Walker, and Co. of Bristol. This engine has been built for a 3 ft. 6 in. gauge, and it has the driving and trailing wheels coupled, the leading wheels being fitted with Adams' radial axle boxes. The water is carried in wing tanks, and the coal at the back of the footplate. The engine is fitted with the Chatelier counter-pressure brake, and the smoke box is provided with a screen for arresting sparks, this screen consisting of a perforated plate extending across it just below the level of the blast nozzle. We noticed that Messrs. Fox, Walker, and Co. had adopted the American practice of making their connecting and coupling rod brasses so that they cover the ends of the crank pins, and to a great extent exclude dust from the bearings. The principal dimensions of the engine are as follows:—Cylinders 10 in. diameter with 18 in. stroke, coupled wheels 3 ft. in diameter and placed 6 ft. apart from centre to centre, this distance representing the length of the rigid wheel base; leading wheels 2 ft. 3 in. in diameter; total wheel base 11 ft. The boiler contains 96 tubes 1¾ inches diameter outside, and 8 ft. 2 in. long between tube plates, these tubes giving an external heating surface of 359 square feet. The firebox surface is 47·16 square feet, thus making the total surface 406·16 square feet. The

firegrate area is 7·4 square feet, and the weight of the engine 14¾ tons empty, and 18¼ tons in working order, 12½ tons of this latter weight resting on the coupled wheels. The general design of the engine is very neat.

FRANCE.

In the French section of the Machinery Hall we found the locomotive builders of France represented by three of their number only, namely, Messrs. Schneider and Co., Messrs. Chaparède and Co. and the Compagnie de Fives-Lille, (Etablissement Parent, Schaken, Houel, et Caillet), the two firms first-mentioned exhibiting goods locomotives, while the third showed a small six-coupled tank engine intended for service on a light narrow gauge line. Of French passenger locomotives no example was shown.

Goods locomotive for the Southern Railway of France, by Schneider and Co.—The engine exhibited by Messrs. Schneider and Co., was one of 20 ordered from the firm for working the goods traffic over portions of the Chemin de Fer du Midi having heavy grades and sharp curves, and it is of a type which has been designed for this service by the engineers of the railway company (see Plates LXXX., LXXXI., and LXXXII.). The objects kept in view in working out the design were to avoid a weight of more than 13 to 14 tons per pair of wheels, to give flexibility for traversing curves of 300 metres (984 ft.) radius, and to take at a speed of 20 kilometres (12½ miles) per hour, the heaviest loads possible up gradients of 32 in 1,000, or 1 in 31·1 from 15 to 16 kilometres (9·36 to 10 miles) in length. These conditions are just such as might, in our opinion, have been admirably fulfilled by the adoption of the Fairlie system, and we venture to say that had that system been resorted to, engines would have been obtained which, with but about the same, or perhaps rather less total weight, would have far exceeded in performance those forming the subject of the present notice. We do not propose, however, to enter here into any enumeration of the advantages which the Fairlie system possesses over the various types of eight-coupled locomotives so largely used for heavy goods traffic on the Continent, but intend for the present to confine ourselves to a description of Messrs. Schneider's engine.

The engine under notice, then, is provided with a light tender, the weight of the latter when fully loaded with water and fuel being but 18 tons. The weight of the tender is in fact kept within reasonable limits by its being made to carry but a very moderate allowance of water, advantage being taken of the fact that, on the parts of the line where these engines have to work, the watering stations are very frequent. The tender was not exhibited at Vienna.

As will be seen from the engravings, and from the Table of dimensions given hereafter, the engine has outside cylinders 21¼ in. in diameter by 24·016 in. stroke, outside valve gear, inside frames, and eight coupled wheels 47·24 in. in diameter, the axles being all situated under the barrel of the boiler. To facilitate the passing of the sharp curves also, the leading and trailing axle boxes are allowed a lateral play in their guides of 0·79 in., the spring pins having double inclined ends bearing upon the axle boxes, so that the weight always tends to maintain the latter in a central position. From the dimensions just stated it will be seen that the tractive force exerted by the cylinders will amount to :

$$\frac{21{\cdot}25^2 \times 24{\cdot}016}{47{\cdot}24} = 229{\cdot}54 \text{ lb.}$$

for each pound of effective pressure per square inch upon the pistons, and as the boiler pressure is 128 lb. per square inch, it is possible that at the slow speed of 12½ miles per hour above mentioned, an effective pressure of nearly or quite 80 lb. per square inch could be maintained upon the pistons, thus giving a tractive effort at that speed of $80 \times 229{\cdot}54 = 18{,}363{\cdot}2$ lb.; while, as the weight of the engine in working order is a little over 53 tons, the adhesion would be ample for utilizing this tractive effort under all ordinary circumstances. At the speed of 12½ miles per hour, or 1,100 ft. per minute, the exertion of the tractive force just mentioned would equal the development of

$$\frac{18{,}363 \times 1{,}100}{33{,}000} = 612{\cdot}1$$

effective horse power, while as the total heating surface (taking external tube surface) is 2,363 square feet, each square foot of surface would, under the above circumstances, have to generate steam sufficient for the development of 0·259 horse power. Considering the large proportion of tube surface and the excessive length of the tubes, we should be inclined to regard this as a maximum performance, only attainable under very favourable circumstances.

Referring to the engravings, it will be seen that there are many points of structural detail worthy of special notice. As will be seen from the Table of dimensions subjoined, the boiler is of unusually large dimensions. It is made with a flush-topped firebox casing and a large dome near the smokebox end, this dome containing the regulator. As is shown by the longitudinal section (Plate LXXXI.), the regulator is a horizontal double gridiron valve, arranged to give first a small and then a larger opening, while the steam is not taken from the highest point of the dome as is usual. Two safety valves are provided, one on the top of the main dome, and the other on the top of a small dome over the firebox. The levers of these valves are prolonged past their fulcra, the prolongation of each lever being curved downwards, so that in the event of the spring balance being carried away, this end of the lever strikes on a stop and prevents the valve from being blown out. This arrangement of safety valve levers was also employed on some other locomotives exhibited at Vienna, but we certainly do not admire it, as it affords too great a facility for the stopping of the proper action of the valves by reckless drivers. The small hind dome is a brass casting, and an opening is formed through it for the passage of the regulator rod, as shown by the transverse section. The same view also shows how the casting is formed so as to take off steam at the highest point for the supply of the injector steam cock.

The smokebox tube plate and the back plate of the firebox casing are supported by transverse stiffening stays, each formed (with the exception of the upper one at the trailing end) of a pair of plates placed together and flanged outwards, so as to give a kind of ⊥ section and form a base for attachment to the plates to be stiffened (see longitudinal section). The lower stiffening stay at the leading end, and the middle stay at the hind end, are extended so as to join the barrel plates and the side plates of the firebox casing respectively; but they are not carried sufficiently far from the plates they stiffen to form gusset pieces; and, in fact, no gusset stays or longitudinal stays are employed.

The firebox crown is supported by girder roof stays placed transversely, the ends of these stays extending over the side water spaces, and resting upon supports formed on the inner side of a kind of joint strip which extends along each side of the firebox casing and forms the connexion between the side and crown plates. This joint strip has also formed on it (as shown by the transverse section, Fig. 3, Plate LXXXII.) a series of bosses for the washing-out plugs, of which there are eight on each side. The use of a connecting strip of this kind is novel to us. It will be noticed from the transverse section that the roof stays, which are each composed of two plates rivetted together with the stay bolts between them, decrease in depth towards the ends, and that no sling stays are used.

As will be seen from the longitudinal section and from one of the transverse sections, the smokebox is reduced in capacity by a partition fixed across it about 4 in. above the level of the top row of tubes. The chimney, it will also be noticed, is carried down, and made to join this partition by a short tapered piece or bell-mouth. About 2 in. below the partition is fixed a horizontal grating or spark arrester, which extends right across the smokebox, while the blast nozzle, which is adjustable, passes through this grating, and terminates just within the bell-mouth already referred to. The grating just mentioned consists merely of a number of parallel bars extending transversely, as shown in the longitudinal and transverse sections; but from the very short distance between this grating and the partition or real top of the smokebox, it appears very doubtful if anything like the full area of the grating can be effective.

The boiler is fed by one No. 10 injector with fixed nozzles, placed on the left side of the engine, and one pump with a plunger 5½ in. diameter and

5·67 in. stroke, placed on the right-hand side, this pump being driven by an eccentric on the leading axle, as shown by the half-plan given on Plate LXXX. The reason for employing a pump is that the engine is fitted with the Le Chatelier counter-pressure apparatus, and the pump is provided to feed the boiler when descending long inclines, a time when the air introduced into the boiler by the counter-pressure working might interfere with the action of the injector.

The engine is well framed, the main frames themselves being substantial, and the transverse connexions good. The mode of fastening the cylinders is also good. The axle-box guides are provided with adjusting wedges, and the springs are connected by compensating levers in pairs, the leading and second springs being thus connected, and the driving and trailing springs. The springs for the leading and second axle are situated inside the frames, the spring pins leading from them direct down to the axle boxes. The driving and trailing springs, however, are placed outside the line of the frames, and above the level of the latter, they taking their bearing not directly upon the spring pins, but upon the ends of transverse beams, which in their turn rest upon the spring pins, as shown in the half transverse section at the driving axle. This arrangement of compensating levers, causes the engine to be practically carried upon four points—one on each side, midway between the leading and second wheels, and the others at the sides, midway between the driving and trailing axles. The distribution of weight of the engine is very good, as will be seen from the data given in the subjoined Table, and it may be worth mentioning that this distribution has been attained, not by employing any cast-iron footplate, or equivalent device, but by adding weight to those parts of the engine where the weight so added will produce additional durability. In addition to the Le Chatelier counter-pressure apparatus already referred to the engine is, as will be seen, fitted with a powerful screw hand brake applied to the trailing wheels.

The cylinders, as will be seen from the transverse section, have the valve chests on the top, the valve face being inclined downwards towards the hind end. The link motion is of the shifting link type, arranged as shown in the side elevation, the block on the link being coupled to a dummy valve spindle working in a stuffing box formed in the valve chest, and an arm from this spindle working the valve spindle proper. The relative position of the two spindles is shown by the half-transverse section at the leading axle. The valve gear is proportioned so as to give a very long period of admission when in full gear, and the reversing is effected by a screw, the reversing lever being hung from a fixed point above the screw, as shown in the side elevation.

The leading and trailing axles are, as we have already mentioned, allowed a lateral play of 0·79 in., and to accommodate this the front and hind lengths of the coupling rods are so jointed to the central length as to be flexible horizontally as well as vertically. The form of this joint is shown by the side elevation and sectional plan, from which it will be seen that the fork at one end of the front and hind coupling rods embraces a vertical pin, which is capable of turning in the jaws formed at the ends of the central length of the coupling rod. The head at each end of each central length of the coupling rod has its lower side made loose and secured by bolts, as shown.

Of the general external design, and minor fittings of the engine, little need be said here, as the leading features are all clearly shown by the engravings. The footplate, it will be noticed, is sheltered by a simple cab, and a sand-box is provided fitted with sand valves worked from the footplate, the sand pipes feeding the sand between the second and driving wheels, and being branched at their lower ends, as shown in the side elevation and longitudinal section.

Of the general finish of the engine exhibited by Messrs. Schneider it is impossible to speak too highly; it having been, in fact, one of the most highly finished, if, indeed, not *the* most highly finished locomotives shown at Vienna; while the polish of all the working gear was such as is only obtainable where exceptionally good materials are used. In conclusion, we append a list of the chief dimensions of the engine we have been describing:

Cylinders:	ft.	in.	*Cylinders*—cont.	ft.	in.
Diameter - - -	1	9¼	Distance apart from centre to		
Stroke - - - -	2	0·016	centre - - -	6	10·68

Cylinders—cont.	ft.	in.
Distance between centres of valve spindles	7	3
Length of ports	1	2⅛
Width of steam ports	0	1·77
„ exhaust „	0	3·15
Working gear:		
Diameter of piston rods	0	2·95
Length of connecting rods between centres	8	3·2
Section of connecting rods at small end 3·74 in. × 2·05 in.		
Section of connecting rods at large end 4·72 in. × 2·05 in.		
Section of coupling rods; central length 3·54 in. × 1·42 in.		
Section of coupling rods; front and hind lengths 3·15 in. × 1·42 in.		
Connecting rod bearings at crosshead 3·74 in. in diameter × 3·62 in. long.		
Connecting rod bearings at crank pin 5·12 in. in diameter × 5·51 in. long.		
Bearings of coupling rods; leading and trailing crank pins 3·54 in. in diameter × 3·15 in. long.		
Bearings of coupling rods; crank pins of second wheels 3·94 in. in diameter × 3.94 in. long.		
Bearings of coupling rods; driving crank pins 5·91 in. in diameter × 3·94 in. long.		
Distance between guide bars	0	11·8
Width of guide bars	0	5⅛
Length of crosshead blocks	1	3
Distance laterally between centre lines of link motion	8	4
Inclination of centre line of valve spindles 131 per 1,000.		
Diameter of valve spindles	0	1·89
Length of slide valves (in the direction of length of ports)	1	4·93
Width of slide valves	0	11 3/32
Outside lap of valves	0	1·18
Inside lap of valves	0	0·12
Maximum lead	0	0·266
Minimum „	0	0·088
Range of cut off; from 5 to 80 per cent. of stroke.		
Maximum travel of valves	0	5·9
Throw of eccentrics	0	2·95
Angular advance of eccentrics 30 deg.		
Wheels and axles:		
Diameter of wheels	8	11·24
Distance between centres of leading and second wheels	4	3·18
Distance between centres of second and driving wheels	4	2·39
Distance between centres of driving and trailing wheels	4	2·39
Total wheel base	12	7·96
Lateral play of leading and trailing axles	0	0·79
Diameter of all axle bearings	0	7·87
Length „ „	0	10·24
Distance between centres of bearings	3	6·9
Diameter of axles at wheel seats	0	8·46
Length of wheel seats on leading and trailing axles	0	6·69

Wheels and axles—cont.	ft.	in.
Length of wheel seats on second and driving axles	0	7·09
Distance between centres of crank pin bearings; leading	5	9·83
Distance between centres of crank pin bearings; second	5	11·65
Distance between centres of crank pin bearings; driving and trailing	6	0·44
Springs:		
Length between centres	2	10·65
Width of plates	0	3·54
Thickness of plates	0	0·474
Number „	13	
Brake:		
Diameter of brake shaft	0	3·54
„ „ screw	0	1·65
Pitch of brake screw	0	0 5/16
Frames:		
Distance between frames	3	11 13/16
Minimum depth of frames	0	11·81
Thickness of frames	0	1·22
Length of frames between buffer plates	30	10
Boiler:		
Diameter of barrel	5	0·63
Length „	15	9¾
„ of firebox casing (outside)	6	9·9
Width of firebox casing (outside)	3	10·46
Height of firebox casing (outside)	7	1·48
Length of inside firebox at top	6	0·05
Length of inside firebox at bottom	6	2·8
Width of inside firebox at top	4	0·82
Width of inside firebox at bottom	3	3·37
Height of firebox crown above grate	5	6·54
Diameter of tubes (outside)	0	1·97
Thickness „	0	0·1
Length of tubes between tube plates	16	0·9
Number „	270	
Length of smokebox	3	1½
Diameter of chimney, inside	1	8·9
Height of centre line of boiler above rails	6	6¾
Height of top of chimney above rails	13	11

	sq. in
Sectional area of internal steam pipe	20·17
Sectional area of openings in regulator face	20·45
Sectional area of each steam pipe to cylinders	13·17
Sectional area of each exhaust pipe	30·34
Minimum opening of exhaust nozzle	5·6
Pressure of steam	128 lb. per sq. in.

Heating surface:	sq. ft.
Tubes, outside	2,236
„ inside	2,012¼
Firebox	127
Total with internal tube surface	2,139¼
Total with external tube surface	2,363

Boiler—cont.	sq. ft.
Firegrate area	20·45
Water capacity of boiler with water level 5½ in. above firebox crown	cub. ft. 222·5
Steam capacity of boiler with water level 5½ in. above firebox crown	68·8
Total capacity of boiler	291·3

Weight:	kilogrms.	tons.
Weight of engine empty	47,410	=46·75
Weight in working order:		
On leading wheels	13,200	=12·99
On second „	13,120	=12·91
On driving „	14,225	=14·00
On trailing „	13,365	=13·15
Total		53·05

Goods' Locomotive by Claparède and Co.—Although sent to Vienna by Messrs. Claparède and Co., this engine was not designed by them, but was one of a number they had in course of construction for the Paris and Orleans Railway from the plans of M. Forquenot, the engineer-in-chief of the company. As will be seen from the engravings (Plates LXXXII., LXXXIII., and LXXXIV.), it is a six-coupled engine, with outside cylinders and valve gear, and inside frames, while all the axles are under the barrel of the boiler. The principal dimensions of the engine are as follows :—

Cylinders:	ft.	in.
Diameter	1	6·9
Stroke	2	1·6
Distance apart between centres	6	10·3
Wheels and frames:		
Diameter of wheels	4	6·2
Distance between centres of leading and driving wheels	6	5·6
Distance between centres of driving and trailing wheels	4	9·5
Total wheel base	11	3·1
Width between frames	4	0·4
Thickness of frames	0	1·1
Total length of engine over buffers	29	3
Boiler:		
Diameter of barrel inside	4	6·3
Thickness of plates	0	0·51
Height of centre line above rails	6	4·8
Length of inside firebox at top	4	4·75
Length of inside firebox at bottom	4	5·9

Boiler—cont.	ft.	in.
Width of inside firebox at widest part	3	6·
Width of inside firebox at bottom	3	6·3
Height of inside firebox	5	5
Number of tubes	214	
Diameter of tubes outside	0	1·9
„ „ inside	0	1·75
Length of tubes between tube plates	14	4·8
Heating surface:		sq. ft.
Firebox		93·6
Tubes, external		1541·4
„ internal		1413·3
Total with external tube surface		1635
Total with internal tube surface		1506·9
Firegrate area		15·9
Pressure of steam	114 lb. per sq. in.	
		tons.
Weight of engine empty		33·97
„ „ in working order (nearly equally distributed)		37·9

It will be seen from the above dimensions that the engine is of a powerful class, the tractive force it is capable of exerting being

$$\frac{18\cdot9^2 \times 25\cdot6}{54\cdot2} = \frac{357\cdot2 \times 25\cdot6}{54\cdot2} = 168\cdot7 \text{ lb.}$$

for each pound of effective pressure per square inch on the pistons. With a mean effective pressure of 90 lb. per square inch, the engine would thus exert a pull of 15,183 lb., or rather less than 18 per cent. of the weight available for adhesion. The manner in which the pull of the engine is transmitted to the framing, is a special point which we must notice here. Instead of being attached direct to the framing at the trailing end, the draw-bar is coupled to the centre of a beam which extends across the engine beneath the footplate, and which is connected by a pair of side rods or links to a similar transverse beam arranged under the boiler between the driving and trailing wheels, this latter beam oscillating on a centre held by transverse stays. The pull is thus transmitted to a point well forward, and the engine is left more free to adjust itself to the road than is the case when the draw-bar is coupled to the fraem direct at the trailing end.

The boiler has a flush-topped firebox casing, and very large dome; but it possesses no special peculiarities requiring notice here, except that we may mention that the tubes are steadied by passing them through a guide plate fixed near the centre of the length of the barrel, as shown in the transverse section. This is a plan which used at one time to be resorted to in this country, but which has long been abandoned here. The cylinders are fixed as shown in the transverse section (Plate LXXXIV., Fig. 1), a projection from each cylinder fitting an opening in the frame so as to relieve the strain on the bolts, and the

frames themselves being well stayed at the smokebox end. The valve chests are situated above the cylinders, the valve faces being inclined both longitudinally and transversely, as shown. In addition to the ordinary cylinder cocks, the cylinders are fitted with spring-loaded relief valves fixed on each cover, as shown in the side elevation, Plate LXXXIII.

The piston rods are carried through the front cylinder covers, and the working gear generally is of heavy proportions. The valve gear is of the stationary link type, and the radius rod is coupled to a "dummy" valve spindle carrying an arm from which the true valve spindle is driven. The outer end of the "dummy" spindle is guided by an unnecessarily massive guide arranged as shown in the side elevation, the legs of this guide entering sockets cast on the cylinder, and being secured in place by cotters. The whole forms a costly arrangement, and one difficult to adjust. The coupling rods are connected so as to be flexible both horizontally and vertically, the pin at the hind end of each of the front lengths being made with a spherical centre, and each hind length of coupling rod being fitted with a movable wedge piece and cotter, to enable this spherical centre to be inserted. The arrangement is similar to that adopted in the case of the Italian locomotive, and of which we shall speak hereafter. The driving end of each hind length of coupling rod also has the upper side made loose to admit the brasses, this upper side being secured in place by a couple of bolts. The leading and driving springs are arranged inside the frames directly over their bearings, as shown in the transverse section, Plate LXXXIV., Fig. 1; the trailing springs, however, are arranged above and outside the line of the frames, they resting upon the ends of a transverse beam, from which the pressure is transmitted by pins to the trailing axle boxes.

The engine we have been describing belongs to a class which we believe do their work satisfactorily, but we must certainly suppose that æsthetic principles were entirely disregarded in their design. The cab provided is decidedly ugly, while the footplate placed at it is at various levels, and terminating as it does with a slope at the trailing end for the length of the handrail plate, imparts a very crude character to the general appearance. The latter is also not improved by the effect of the brass lagging plates, which, as in many French locomotives, are used for covering the boiler, dome, and sand-box. The engine shown at Vienna had not been specially prepared for exhibition, but was merely sent as a sample of the ordinary work of the makers. The working parts, we may add, were left just as they came from the machine tools.

Tank Locomotive for a One-Metre Gauge by the Compagnie de Fives-Lille.—The small tank engine from the Compagnie de Fives-Lille (Etablissement Parent, Schaken, Houel, et Caillet), of which we have next to speak, is, as will be seen from the outline views given on Plate LXXXVI., a six-wheeled engine with outside cylinders, outside valve gear, inside frames, and wing tanks, while it is constructed for a line of one metre (3 ft. 3⅜ in.) gauge. Its principal dimensions are as follows:—

	ft.	in.
Diameter of cylinders	0	9·84
Stroke	1	2·17
Diameter of wheels	2	7½
Wheel base	5	7·7

Heating surface:	sq. ft.
Firebox	38·7
Tubes	277·7
Total	316·4

Heating surface—cont.	
Firegrate area	6·8
Contents of tanks	352 gals.
„ of coal bunkers	6 cwt.
Weight of engine empty	11 tons.
„ „ in working order	14 „

The boiler pressure is 8¼ kil. per square centimetre, or 117·2 lb. per square inch, and the engine is stated to be capable of exerting a pull of 1,600 kils., or 3,520 lb. The tyres of the centre pair of wheels are without flanges, so as to facilitate the passage of sharp curves, and the trailing wheels are made the driving wheels, the connecting and eccentric rods being very long. The valve gear is of the ordinary lifting link type, with box links, and provided with screw reversing gear. We may add that the engine we have been describing illustrates one of seven different sized engines of the same general type constructed by the Compagnie de Fives-Lille these engines varying in

weight from 14 tons to 36 tons in working order. The designs of these engines are such, moreover, that each size may be fitted with wheels of three different diameters, according to the nature of the traffic to be worked, and thus altogether twenty-one varieties are obtained. The general finish of the engine exhibited was rough, but the engine is nevertheless of a type which would no doubt do good service with moderate loads on the light class of lines for which it is intended.

Italy.

Goods Locomotive by the Societá Nazionale d'Industrie Mechaniche, Naples.—Italy was represented at Vienna by a single locomotive, this being a six-coupled engine with its tender, exhibited by the Societá Nazionale d'Industrie Mechaniche, of Naples. The workmanship of this engine was rough, and the design in many respects not what it should be. Amongst the peculiarities of detail we may notice the mode of connecting the front and hind portions of the coupling rods. Instead of the two parts being simply connected by a pin passing through single and double eyes on the ends of the front and hind lengths, as usual, the front length is made as shown in the sketch (Fig. 2, Plate LXXXIV.), the pin of the hind length, which is forked, being secured by a sliding piece *a* and cotter *b* as shown. The object of this arrangement is to enable a spherical form to be given to the centre portion of the coupling pin; but we regard the whole affair as an unnecessary complication. The wheels of the engine under notice appeared to have been tamped on Arbel's system, and they looked rather light. The cylinders were outside, as in all other six-coupled engines in the exhibition; but the valve gear was inside, and was of the shifting link pattern, with screw reversing gear. The tender was carried on four wheels, and included no special points requiring notice.

Belgium.

Goods Locomotive and Contractors' Locomotives by the Société John Cockerill.—Belgium we found represented by six locomotives, two of these being shown by the Société John Cockerill, of Seraing. One of the locomotives exhibited by this firm was a six-coupled outside cylinder goods engine, of very substantial design and excellent finish, which we illustrate on Plate LXXXV., on which plate the leading dimensions are also given. The valve gear, which is of the ordinary shifting link pattern, is inside, and is fitted with screw reversing gear. We noticed that in this engine, as in several others in the Exhibition, the old form of square valve spindle guides was retained, although it has long been almost universally discarded in this country in favour of the more simple and easily fitted circular form. The piston rods are carried out through the front covers, a practice which is now largely resorted to on the continent for the purpose of giving extra support to the piston and promoting the equal wear of the cylinder, but which is attended with some disadvantages. The second engine by the same makers was a small four-wheeled tank engine with a vertical boiler, evidently intended for contractors' purposes or similar work. The cylinders, which are outside, are fixed at a rather steep angle, so that they may be placed over the leading wheels. The valve gear is inside. The boiler is fed by one injector and one pump, the latter being arranged on the top of one of the cylinders and worked from the crosshead. The water is carried in a tank of horseshoe form in plan, which partly surrounds the boiler, the prolongation of the sides of the horseshoe forming the fuel bunkers. This engine was rather roughly finished; but the workmanship appeared to be otherwise good.

Passenger Locomotive by the Société Anonyme de Marcinelle et Couillet.—The third engine shown in the Belgium section was that by the Société Anonyme de Marcinelle et Couillet (Plate LXXXIV., Fig. 3). This engine had been constructed for the Grand Central Railway of Belgium, on which line a number of locomotives of a similar pattern are now running. Five of these engines were started in 1864, two in 1865, and 14 in 1867, while seven others were at the time of the Exhibition in progress at the works of the makers of the engine under notice.

Up to the commencement of the summer of 1873 the locomotives just mentioned had, we are informed, been in service for periods amounting in the aggregate to 1,604 months, and during that time they had run altogether 3,916,514 miles, the average monthly mileage per engine being thus 2,442 miles. They take, in ordinary service, trains of 21 vehicles at a speed of 60 kilometres (=37·26 miles) per hour over a line with a gradient of 1 in 200, or trains of nine vehicles at a speed of 40 kilometres (=24·84 miles) per hour over a gradient of 1 in 55, which separates the Planche station from that of Lodelinsart. The mean consumption of fuel per engine per mile has been 34·2 lb. of the small semi-bituminous coal of the Charleroi basin, a very low consumption, considering the generally heavy character of the line on which they are being worked.

Referring to the illustration (Plate LXXXIV.) it will be seen that the engine has inside frames, outside cylinders, and outside valve motion, the latter having some special features, of which we shall speak presently. The two hind pairs of wheels are coupled, and the cylinders are placed between the leading and central pairs of wheels, the hind wheels being the driving wheels. The cylinders are $17\frac{5}{16}$ in. in diameter, with 1 ft. $11\frac{5}{8}$ in. stroke, and the coupled wheels are 6 ft $10\frac{5}{8}$ in. in diameter. This large diameter of wheels, combined with the position of the cylinders, has rendered extremely long guide bars—their length is over 7 ft.—necessary, and these bars appear to us to be rather weak, notwithstanding that they are stayed together as shown.

The two axles of the coupled wheels are equidistant from the firebox casing, while the leading wheels are placed well forward. The axle-box guides for the coupled wheels are fitted with adjusting wedges, and the springs are connected by compensating beams, stops limiting the movement of these beams as shown.

The boiler has a Belpaire firebox, with a firegrate adapted for burning small coal, the bars being $\frac{5}{16}$ in. thick, and placed $\frac{5}{16}$ in. apart. The firebox stays are drilled for a portion of their length. The boiler is fed by two Friedmann's injectors of 7 and 9 millimetres respectively, while the pressure gauge is made on Rau's system, and has a face lit by an internal lamp, a very neat and convenient arrangement.

The working gear is of very neat design and good workmanship. The connecting rod large ends and one end of each coupling rod are made with open forks to receive the brasses, the latter being secured by a distance piece inserted in the fork and traversed by a bolt. This form of end has been frequently used both in this country and on the Continent for connecting rods, but its application to coupling rods is unusual. The cylinders are lubricated by lubricators on the Camozzy and Schloesser's system, and the piston rod and valve-spindle glands are fitted with the metallic packing of the same patentees. The valve motion has, as we have already stated, some special features, and these we must now explain.

The gear is constructed on Guinotte's system, which has, in the present instance, been applied to a locomotive for the first time. The general arrangement and action of the gear will probably be best understood by reference to the skeleton diagram, Fig. 4, Plate LXXXIV.; Fig. 5 showing the valves used. From these views it will be seen that each cylinder is fitted with a main slide, having an expansion valve working on its back, the main slide being driven by the ordinary Walschaert gear, while the expansion valve receives its motion from the supplementary gear, designed by M. Guinotte. In this arrangement the main slide has a constant travel of $4\frac{9}{16}$ in., the Walschaert gear by which it is driven being always worked in full gear, and being only used for reversing.

The expansion valve, on the other hand, has a travel variable from $7\frac{7}{16}$ in. to $2\frac{7}{8}$ in., the motion being given to it as follows:—Referring to the side elevation and to Fig. 4, Plate LXXXIV., it will be seen that in addition to the ordinary expansion link common to the Walschaert gear there is provided a similar but smaller link, placed slightly further forward and at a higher level. This link, which we shall for the purpose of distinction call the supplementary expansion link, has its upper end connected by a rod to a prolongation of the vibrating lever which, in the Walschaert's gear, communicates motion to the

main slide, while it oscillates on a point situated somewhat below its centre, the support on which it oscillates being the upper end of a second vibrating lever, the lower end of which is connected to the crosshead. The supplementary expansion link has thus a compound motion, due to its upper end being connected to the lever actuating the main slide, while its point of suspension is moved by its connexion with the crosshead. From the supplementary expansion link the motion is communicated to the expansion slide by an ordinary radius rod, the position of this rod being governed by a weigh-shaft which is independent of the main reversing lever, and to which for convenience we shall give the name of the expansion weigh-shaft.

The two weigh-shafts are led across the top of the fire-box casing, and for convenience, and to obtain a compact arrangement, the main weigh-shaft has been made tubular, and the expansion weigh-shaft has been carried through it. It is a leading feature in the Guinotte gear that the expansion gear when set for a certain cut off has the same action, whether the engine is going forward or backward, and in reversing the engine it is unnecessary, therefore, to interfere with the expansion gear. The reversing lever works in a quadrant having three notches only, these corresponding to forward, mid, and backward gear respectively; the expansion weigh-shaft, on the other hand, is actuated by a screw, which enables the expansion to be set to any desired amount within the range available. The Table given below gives the action of this gear, as shown by a full-sized model constructed at the workshops of the Grand Central Railway at Louvain; the results recorded in the Table are for fore gear only, but those for back gear are sensibly the same. It may be added that when the expansion gear is set to give full admission, the main gear may be reversed as easily as if there was but a single slide only.

TABLE showing the Performance of the Valve Gear with the Engine moving forward.

Number of Notch.	Lead.	Maximum Opening of the Ports.		Percentage of the Stroke performed during the admission of the Steam.		Percentage of the Stroke performed during the Expansion.		Distance of point of Exhaust from end of Stroke expressed in percentages (Front and Back).	Duration of Exhaust during Exhaust Stroke expressed in percentages (Front and Back).	Duration of Compression in percentages of Stroke (Front and Back).	Travel of Main Slide.	Travel of Expansion Slide.
		Front.	Back.	Front.	Back.	Front.	Back.					
	in.	in.	in.								in.	in.
1	0·197	1·535	1·614	78	78	18	18	4	96	4	4·567	7·48
2	0·197	1·535	1·614	67	67	29	29	4	96	4	4·567	6·06
3	0·197	1·535	1·614	58	57	38	39	4	96	4	4·567	5·39
4	0·197	1·535	1·614	48	47	48	49	4	96	4	4·567	4·84
5	0·197	1·535	1·614	41	40	55	56	4	96	4	4·567	4·41
6	0·197	1·535	1·614	30	30	66	66	4	96	4	4·567	3·86
7	0·197	1·535	1·614	20	20	76	76	4	96	4	4·567	3·31
8	0·197	1·535	1·614	10	11	86	85	4	96	4	4·567	2·87

The distribution recorded by the table is undoubtedly very good, but we ourselves scarcely apprehend that the slight additional economy which the use of the additional expansion gear will effect by reducing wire-drawing and loss due to excessive compression will compensate for the extra complexity and cost of maintenance. Economy of fuel is far from being so important a matter in the case of locomotives as it is with factory, pumping, or marine engines, and to be really economical any reduction in the consumption of fuel must be effected by means that add little to the first cost of an engine, or to the cost of repairs and attendance. For these reasons we do not deem M. Guinotte's gear as applicable to locomotives as it is to the winding and similar engines for which it was first designed, and we anticipate that practical experience will prove this to be the case. The matter will, however, have a fair trial on the Grand Central Railway, as the engine of which we have spoken will

have to run in competition with other locomotives which are precisely similar, with the exception of their not being fitted with M. Guinotte's gear.

The general design of the engine of which we have been speaking is, as will be seen from the engraving on Plate LXXXIV., very neat, while the workmanship and finish are excellent. We append a list of the principal dimensions, together with particulars of the weights and heating surfaces:

	ft.	in.
Cylinders:		
Diameter	1	$5\frac{5}{16}$
Stroke	1	$11\frac{5}{8}$
Distance apart from centre to centre	6	$6\frac{3}{4}$
Distance from centre line of exhaust ports to centre of driving axle	12	6
Length of connecting rods between centres	8	$0\frac{5}{8}$
Wheels and frames:		
Diameter of coupled wheels	6	$10\frac{5}{8}$
„ leading „	3	$11\frac{1}{4}$
Distance between centres of leading and middle wheels	8	$7\frac{9}{16}$
Distance between centres of coupled wheels	7	$6\frac{9}{16}$
Total wheel base	16	$2\frac{1}{8}$
Distance of centres of coupled axles from front and back of firebox casing respectively	0	$7\frac{7}{8}$
Distance from centre of trailing axle to outside trailing buffer beam	4	$10\frac{1}{2}$
Distance from centre of leading axle to outside leading buffer beam	5	3
Total length of engine over buffers	27	$10\frac{1}{2}$
Distance between frames	3	$11\frac{1}{4}$
Least section of frames 1 in. by $12\frac{3}{16}$ in.		
Boiler:		
Length of barrel	10	$6\frac{3}{4}$
Diameter	4	0
Length of firebox casing	6	$2\frac{7}{8}$
Width	3	$9\frac{5}{8}$
Length of smokebox	2	$6\frac{1}{2}$
Diameter	4	$1\frac{1}{2}$
Length of inside firebox	5	7
Width of inside firebox, greatest	3	5

Boiler—cont.	ft.	in.
Width of inside firebox, least	3	$2\frac{9}{16}$
Height of inside firebox, greatest	5	1
Height of inside firebox, least	3	$7\frac{5}{16}$
Thickness of plates of boiler shell	0	0·51
Thickness of plates of inside firebox (copper)	0	0·51
Thickness of firebox tube plate (copper)	0	0·94
Number of tubes 223		
Diameter of tubes outside	0	1·77
Thickness of tubes	0	0·078
Length between tube plates	10	$10\frac{1}{4}$
Diameter of chimney inside, least	1	$4\frac{1}{2}$
Diameter of chimney inside, greatest	1	$9\frac{1}{4}$
Heating surfaces:	sq. ft.	
Firebox		$76\frac{1}{2}$
Tubes (outside)		$1{,}121\frac{1}{2}$
Total with *external* tube surface		1,198
Internal tube surface		1,072
Total with *internal* tube surface		$1{,}148\frac{1}{2}$
Grate area		17·9
Pressure of steam	118 lb. per sq. in.	
Weight of engine empty:	tons.	
On leading wheels		10·75
On coupled „		19·79
Total weight empty		30·54
Weight of engine in working order:		
On leading wheels		11·29
On coupled „		21·32
Total weight in working order		32·61

Passenger Locomotive by M. Charles Carels, Ghent.—We have next to speak of an engine constructed and shown by M. Charles Carels of Ghent, this locomotive being characterized by certain novelties of design which rendered it one of the most remarkable engines exhibited. The side elevations and transverse sections, Figs. 3 and 4, Plate LXXXVI., and Plate LXXXVII., show the arrangement of this locomotive clearly, and will enable our readers to judge how far this statement is justified. The engine, which is intended for heavy passenger traffic, was designed by M. Carels from a suggestion of M. Belpaire, the Inspector-general of the Belgian State Railways, the details of the plans having been worked out by M. A. Stevart; and the leading feature in the construction consists, as will be seen, in placing the cylinders above the footplate level, and communicating the motion from the piston rods to the wheels through the intervention of beams vibrating on centres at the trailing end of the engine, as shown in the side elevation. The advantages claimed for this arrangement are that the working gear is placed immediately under the inspection of the driver; that from the moving parts being well raised above the ground they are less exposed to dust; that as the pistons and their immediate connections move in the opposite direction to the coupling rods, the reciprocating parts are balanced; and that when new wheels have to be put in, the coupling rods only have to be dismounted. We shall content ourselves for the present with merely stating these claims as set forward by the designers, as we shall have, hereafter, to analyse the leading features of the

exhibited locomotives generally, and we shall, therefore, proceed at once with our detailed description of the engine under notice.

Referring to the transverse section, Fig. 4, Plate LXXXVI., it will be seen that the cylinders are bolted down to a strong footplate which is attached to the frames by double angle irons. The two cylinders are identical, there being nothing to make them right or left-handed. The valve face is arranged in an inclined position at the top of each cylinder as shown, and the exhaust passage is led round the latter, an arrangement which greatly tends to promote internal condensation in the cylinder, and which should, therefore, be avoided. The steam pipe connecting the dome with the cylinders is protected by passing it through another larger pipe as shown. Each piston rod passes through both cylinder covers, the hind end being attached to a crosshead working in guides carried by a plate which is secured to the footplate by an angle iron, as shown in the left-hand half of the transverse section. From this crosshead a connecting rod extends to the upper end of the corresponding vibrating beam, of which the lower end is coupled by a longer connecting rod to the crank pin of the trailing wheels, as shown.

The valve motion is a kind of Walschaerts gear, each link, however, instead of being driven by an eccentric, deriving its motion from the vibrating beam on the opposite side of the engine. To give this motion an arm is fixed on the axis of the beam in the position shown dotted in the side elevation, Plate LXXXVII., and from the eye at the end of this arm a rod passes down to a lever on a rocking shaft below. From another arm of this rocking lever another rod extends up to the expansion link on the other side of the engine as shown by the dotted lines in our engraving. There are of course two rocking shafts, one for each set of valve gear. The reversing is effected by a combined lever and screw arrangement.

The boiler has a firebox constructed on M. Belpaire's system, and contains a long grate with close firebars suitable for burning small coal. The construction of this firebox is clearly shown by the transverse section, Fig. 4, Plate LXXXVI. The boiler it will be noticed is so placed as to considerably overhang the wheels at the leading end, and thus to counterbalance the great additional weight which the position of the cylinders would cause to be thrown upon the trailing wheels.

The frames are outside, the axles carrying outside cranks. The springs of the driving wheels and the main springs of the trailing wheels are connected by a very neat system of compensating gear, consisting of a pair of bell cranks connected by a tension rod. The leading ends of the two leading springs are also connected by a somewhat similar arrangement of compensating gear carrying the connexion across the engine. In this case the front end of each leading spring is coupled to a vertical bell crank lever, from which a tension rod extends forwards to one arm of a horizontal bell crank beneath the smokebox, the other arm of this bell crank being connected by a rod to the corresponding arm of a similar bell crank on the other side of the engine. In the case of the trailing wheels it will be noticed that in addition to the main springs, which are connected by compensating gear to the springs of the driving wheels, there are also small auxiliary springs arranged above the trailing axle boxes, as shown in the side elevation.

In addition to the metrical dimensions given in the illustrations we subjoin, for convenience of reference, the following principal dimensions in English measures:

Cylinders:	ft.	in.
Diameter	1	5¾
Stroke	1	11½
Distance apart from centre to centre	7	6⅛
Height of centres above centre line of wheels	3	7½
Wheels:		
Diameter	5	7
Distance between centres of leading and centre wheels	5	10½
Distance between centres of centres and trailing wheels	8	2⅞
Total wheel base	14	1⅛

Frames:	ft.	in.
Total length over buffer plates	29	3½
„ „ buffers	31	9½
Width between frames	6	4⅝
Thickness of frames	0	1
Distance from centre of leading wheels to outside leading buffer beam	8	1½
Distance from centre of trailing wheel to outside of trailing buffer beam	7	1½
Boiler:		
Diameter of barrel	4	3
Length of firebox	8	11

Boiler—cont.	ft.	in.
Width of firebox - -	3	8
Number of tubes - 226		
Diameter „ (outside) -	0	1 $\frac{3}{4}$
„ (inside) -	0	1 $\frac{5}{16}$
Length „ between tube plates - - - -	11	6 $\frac{5}{16}$

Boiler—cont.	square feet
Heating surface—	
Tubes (outside) -	1191·6
Firebox - -	117·4
Total - -	1309·0
Firegrate area - -	32·75
Pressure of steam -	122·3 lb. per sq. in.

In conclusion we may state that whatever opinion may be expressed as to the value of the system of construction of which this engine forms the first example, it is evident that the design has been worked out with great care, the proportions being good except that we have some doubts as to the sufficient rigidity of the cylinder fastenings and of the efficacy of the cross stays for maintaining the "squareness" of the engine.

Passenger Locomotive by the Société Générale d'Exploitation des Chemins de Fer, Tubize.—Fifth on our list of Belgian locomotives we have an exceedingly well-finished six-wheeled passenger engine, with driving and trailing wheels coupled, constructed by the Société Générale d'Exploitation des Chemins de Fer, at their workshops at Tubize. As will be seen from the engraving (Plate LXXXVIII.), the engine has outside cylinders and outside valve gear, the latter being of the Walschaert type. We may mention, by the way, that this valve gear was first applied at the Tubize works, having been introduced there about 1858 on some engines built for the line between Antwerp and Rotterdam. One engine fitted with this gear ran, during the 12 years preceding 1873, 161,000 kilometres, or almost exactly 100,000 miles.

The engine exhibited was of very neat design and good workmanship. The firebox, which is constructed on M. Belpaire's system, is large, and the grate is adapted for burning small coal. The springs of the coupled wheels are connected by a compensating gear, consisting of a pair of bell cranks, and a tension bar, as shown in the side elevation, an arrangement now frequently adopted by Continental locomotive builders, and one which has much to commend it. While speaking of the springs, we may notice also a little constructive detail which is now largely adopted on the Continent, and which is to be seen on the engine with which we are now dealing. The detail to which we refer is a mode of forming the ends of the springs so as to get a knife-edge bearing for the washers under the adjusting nuts on the spring links; and it is shown by Fig. 6, Plate LXXXVI. The top plate of the spring is, as will be seen, bent back on itself, and it is bulged upwards to form the knife-edge bearing as shown. The proportions of the motion generally are good, but the connecting, coupling, and eccentric rods are grooved on the outside only instead of being made of the true I section. This is a defect which mars a good design. We notice also that the plan has been adopted of bolting the valve spindle guides to the top guide bars. This arrangement is frequently used by continental locomotive builders in cases where the Walschaert gear is employed; but it is a faulty one, as the guide bar cannot be "let up" without readjusting the valve spindle guide by the interposition of a liner between it and the guide bar. The defect we have just pointed out exists also in some other engines in the Exhibition.

The guide bars in the engine we are now describing are made with loose wearing pieces of steel, secured to the bars by screws. These wearing pieces are of the form shown by the sketch, Fig. 5, Plate LXXXVI. It will be seen from this that the wearing piece is grooved in the centre, a fin or feather on the crosshead block entering this groove, and giving the necessary guidance laterally. It will be seen from the side elevation, Plate LXXXVIII., that the crosshead blocks are dovetailed on to the main body of the crosshead. This is rather an expensive mode of connection. The connecting rods have large ends of the open-fork pattern, the brasses being retained by a piece secured by a vertical bolt, and set up by a wedge and screw. The coupling rods are also fitted with wedges and screws for adjusting the brasses, and the proportions are good, and the details neatly worked out.

The principal dimensions of this engine are as follows :

	ft.	in.
Cylinders:		
Diameter	1	$4\frac{17}{32}$
Stroke	1	$11\frac{5}{8}$
Distance apart from centre to centre	6	$7\frac{13}{16}$
Distance between the centres of valve spindles	7	$6\frac{7}{16}$
Distance between centres of expansion links	7	$6\frac{7}{16}$
Wheels:		
Diameter of coupled wheels	5	$10\frac{7}{8}$
Diameter of leading wheels	3	$7\frac{5}{16}$
Distance between centres of leading and driving wheels	6	$8\frac{11}{16}$
Distance between centres of coupled wheels	7	$4\frac{9}{16}$
Total wheel base	14	$1\frac{1}{4}$
Diameter of axle bearings	0	$7\frac{7}{16}$
Length " "	0	$9\frac{13}{16}$
Distance between centres of bearings	3	$7\frac{7}{8}$
Frames:		
Thickness of frames	0	$1\frac{3}{16}$
Distance between frames	4	$1\frac{3}{8}$
Length of frames between buffer beams	26	$4\frac{7}{16}$
Length of engine over buffers	29	$5\frac{1}{2}$
Boiler:		
Diameter of barrel	4	$3\frac{7}{16}$
Length	11	$9\frac{3}{8}$
Thickness of plates	0	$0\frac{23}{32}$
Height of centre line above rail	6	$10\frac{5}{8}$
Total capacity of the boiler, $194\frac{1}{2}$ cub. ft.		
Volume of water in boiler with water level $3\frac{15}{16}$ in. above fire-box crown = $134\frac{1}{4}$ cub. ft.		

Boiler—cont.	ft.	in.
Number of tubes 217		
Diameter " (inside)	0	$1\frac{3}{4}\frac{7}{2}$
" " (outside)	0	$1\frac{4}{5}\frac{9}{2}$
Length " between tube-plates	12	$0\frac{7}{8}$
Length of inside firebox (inside)	7	$2\frac{5}{8}$
Width of inside firebox (inside)	3	$4\frac{3}{8}$
Height of crown above grate (mean)	3	$5\frac{5}{16}$
Thickness of plates (copper)	0	$0\frac{5}{8}\frac{3}{2}$
" tube plate "	0	1
Length of smokebox	2	$5\frac{1}{2}$
Width "	4	$3\frac{3}{16}$
Diameter of chimney (inside)	1	$6\frac{1}{2}$
Height of top of chimney above rail	14	$2\frac{1}{2}$

Heating surfaces:	square feet.
Firebox	94·7
Tubes (outside)	1215·3
Total	1310·0
Firegrate area	24·3

Weight:	tons.
Weight of engine empty	32·5
" " in working order:	
On leading wheels	10·9
" driving "	12·89
" trailing "	12·15
Total	85·94

The tender by which the engine was accompanied is, as is shown by Plate LXXXVI., Fig. 2, mounted on four wheels, and its tank is capable of containing 1760 gallons of water, while there is storage for three tons of fuel. A brake is applied to all the wheels, the brake shaft being, as will be seen, carried in bearings formed on the brake-block hangers belonging to the front wheels. This shaft is turned by a screw acting on a lever, as shown, while from other arms on the brake shaft thrust rods extend to the brake blocks applied to the hind wheels. The arrangement gives an equal pressure on the brake blocks, and dispenses with separate hangers for carrying the brake shaft. The tender weighs 10 tons empty, and 21 tons in full working order.

Altogether the engine and tender we have just been describing are very well designed and well fitted for the service they are intended to perform, namely, that of hauling fast passenger trains on lines having gradients not exceeding 15 per 1,000, or about 1 in 66.

Double-Bogie Locomotive on Meyer's system, by the Compagnie Belge, Brussels.—The last of the locomotives in the Belgium section was a double-bogie engine on the Meyer system constructed by the Compagnie Belge, of Brussels (a company of which M. Charles Evrard is the managing director) for the Grand Central Railway of Belgium. Of this engine, which is to be employed on the line to Lodelinsart, we give a side elevation and half plan, and a longitudinal section and half sectional plan and also cross sections, in Plates LXXXIX. and XC., and Figs. 1 and 2, Plate XCI., these several views explaining the construction of the engine fully.

In describing the engine under notice we should state in the first place that the design was planned under the direction of M. Maurice Urban—the engineer-in-chief of the Grand-Central Belge—by M. Wehrenpfening, with the co-operation of MM. Meyer; while M. Belleroche had charge of the execution of the work. The detailed constructive drawings for the engine were got out at the offices of the Compagnie Belge under the direction of the engineer in-chief, M. Rousseau, while to the builders are also due the designs

for the arrangement of steam pipes, the reversing gear, the construction of the centre for the leading bogie and other important details.

Referring to our illustrations it will be seen that the engine is provided with two steam bogies, each having six coupled wheels. The boiler, which is of the Belpaire type, but of course of unusually large dimensions, is carried on three points, namely, one on the front and two on the hind bogie, the positions and construction of these points of support being clearly shown by our engravings. The firebox has an inclined crown as shown.

The bogies are fitted at their inner or adjoining ends with a hollow central buffer, through which the connecting draw bar passes, while at their outer ends they are each provided with the usual pair of buffers to meet those on the trains. The centre bearing point on the leading bogie is placed $5\frac{7}{8}$ in. in advance of the central axle of that bogie, and it consists of a cap of phosphor-bronze suitably connected to the boiler and bearing upon the spherical head of a cast-iron pin attached by plates and angle irons to the frames of the bogie. The connexion between the phosphor-bronze cap and the boiler is made by a box of wrought-iron plates which serves to conduct the exhaust steam to the blast pipe in the smokebox, the steam entering the box just mentioned through the hollow bearing pin, with which the exhaust pipe from the two pairs of cylinders is connected.

The two supports for the boiler on the hind bogie are fixed directly to the frames of that bogie and are made of cast steel. The sliding plates which rest on these supports are also of cast steel, and are provided at their centres with spherical bearings, similar to those used on Engerth's engines, these, by means of brackets of phosphor-bronze, being made to serve as the supports for the firebox end of the boiler. The supports of which we have just been speaking are placed $5\frac{7}{8}$ in. behind the central axle of the trailing bogie, and the longitudinal distance between the front and hind supports of the boiler is thus 20 ft. $\frac{3}{4}$ in.—a very long span. The bogie frames are well braced by cross stays, and they are fitted with cast-steel axle box guides and adjusting wedges. The axle boxes are of wrought iron case-hardened, while the wheels, which are also of wrought iron, have the balance weights forged in one piece with them, and are fitted with steel tyres and axles.

The thrust of the hind bogie is transmitted forwards by the central buffer already mentioned, while the connecting draw gear between the two bogies consists of a collar surrounding the front pin, of two oblique rods jointed in a horizontal plane, and of a draw bar which traverses the hollow central buffer and is attached to the hind bogie by a Stradal draw apparatus. The draw gear at the outer ends of the bogies is also of the Stradal type, an arrangement of draw apparatus which we regard as worthy of extensive adoption.

The cylinders, which are outside, are at the inner or adjoining ends of the bogies, and the valve chests are on the top of them, the valve gear being of the Walschaert type. The boiler is provided with an independent regulator for each pair of cylinders, the arrangement of steam pipes employed being clearly shown by our illustrations. The exhaust steam from the cylinders of the trailing bogie is led through a jointed pipe between the two bogies to join that from the front pair of cylinders, the whole of the exhaust eventually passing, as we have already explained, through the hollow centre pin to the blast pipe.

Each bogie has its independent reversing gear, the reversal in the case of the leading bogie being effected by a screw, and in that of the hind bogie by a lever. By means of a neat arrangement the reversing gears can be coupled by merely throwing a catch into gear, and they can then be operated together by means of the screw already mentioned. The arrangement of jointed rods for connecting the reversing gear proper with the valve motion of the two bogies will be best understood by reference to the illustrations. The pistons are of wrought iron and are of the Swedish pattern with cast-iron rings. The piston rods, slide bars, coupling rods, and connecting rods are of cast steel, and the general design and proportions of all the working gear are very good. The connecting rods, we may remark, are very long, their length between centres being 8 ft. $4\frac{3}{8}$ in.

The water tanks and fuel bunkers are fixed at the sides of the boiler and not on the bogie frames, as in MM. Meyer's former engine, the Avenir, an arrangement which was decidedly faulty. The boiler is fed by a couple of Friedmann injectors placed below the footplate.

Brakes are fitted to both the bogies, that on the hind bogie consisting of a pair of brake blocks applied to the hind wheels by means of a screw, while the front bogie is furnished with a steam brake. This latter consists of a cylinder of which the piston carries a crosshead acting upon the levers of the brake shaft through the intervention of vertical links, and thus applying the brake blocks.

The steam is admitted to or released from the brake cylinder by a single pipe, and it exerts pressure against the underside of the piston, the taking off of the brake being effected by the descent of the moving parts. The brake blocks are all of wood, and the brake hangers are fitted with india-rubber bearing rings so as to obtain an elastic connexion with the bogie frames. The engine is in addition to the brakes above mentioned, fitted with Le Chatelier's counter-pressure apparatus.

In addition to the metrical dimensions given on our illustrations, we subjoin the following list of principal dimensions in English measures.

	ft.	in.
Cylinders (two pairs):		
Diameter	1	$5\frac{15}{16}$
Stroke	1	$7\frac{1}{16}$
Distance apart from centre to centre	6	$7\frac{1}{2}$
Frames of Bogies:		
Distance apart	4	$1\frac{3}{16}$
Thickness	0	1
Least depth	1	$5\frac{1}{16}$
Total length of engine over buffers	41	$11\frac{1}{4}$
Wheels:		
Diameter	4	0
Distance between outer and centre wheels of each bogie	4	$3\frac{1}{4}$
Distance between centre and inner wheels of each bogie	4	$5\frac{1}{2}$
Wheel base of each bogie	8	$8\frac{3}{4}$
Total wheel base of engine	27	$7\frac{3}{4}$
Boiler:		
Length of barrel including smokebox	18	$0\frac{1}{2}$
Diameter of barrel (outside)	4	11
Thickness of plates	0	$0\frac{33}{64}$
" " at strengthened parts	0	$0\frac{37}{64}$
Height of centre above rails	7	$5\frac{1}{4}$
Length of firebox casing	9	6
Width of firebox casing (greatest)	5	$1\frac{5}{16}$
Width of firebox casing (least)	4	$10\frac{5}{8}$
Thickness of plates	0	$0\frac{33}{64}$
Length of firebox, inside	8	$9\frac{1}{2}$
Width of firebox, inside (greatest)	4	$3\frac{5}{16}$

	ft.	in.
Boiler—cont.		
Width of firebox, inside (least)	4	$0\frac{1}{16}$
Height of crown above grate at back	2	$9\frac{3}{4}$
Height of crown above grate at front	4	$4\frac{1}{4}$
Number of tubes 239		
Diameter " outside	0	$1\frac{3}{4}$
" " inside	0	$1\frac{5}{8}$
Length " between tube-plates	14	$9\frac{1}{2}$
Diameter of chimney at top	2	2
" " bottom	1	10
Height " above rails	14	$3\frac{1}{4}$

Heating surface:	square feet.
Tubes (outside)	2,190
Firebox	$128\frac{1}{2}$
Total	$2,327\frac{1}{2}$

Firegrate area - 36 square feet.
Capacity of boiler - 304 cubic feet.
Pressure of steam - 132 lb. per square in.

	tons.
Weight of the engine empty	55·4
Contents of tanks=1,640 gallons	7·45
Fuel in coal boxes	3·00
Water in boiler	5·00
Coal on grate, say	0·50
Tools and equipments	0·55
Weight of engine in full working order	71·9
Cost of engine - 4,800*l.*	

The workmanship and general finish of the engine were very good, and did much credit to the constructors.

So far we have only confined ourselves to a mere description of the Meyer engine shown at Vienna; but it would be unjust to Mr. Fairlie who has so successfully accomplished the practical introduction of the double-bogie system of locomotive if we did not here point out the leading differences between the Meyer and Fairlie systems. As will be seen on reference to the engravings of the Meyer engine, MM. Meyer retain the ordinary form of locomotive boiler, and hence they are compelled, in order to get sufficient heating surface, to adopt an exceptionally large diameter of barrel and great length of tubes. In the engine exhibited at Vienna the barrel of the boiler was, as we have stated, 4 ft. 11 in. in diameter and the tubes 14 ft. $9\frac{1}{8}$ in. long. But these large single boilers are at a considerable disadvantage as regards weight for a given efficiency as compared with Mr. Fairlie's double boilers with central firebox, whilst the large diameter of their barrels renders

them unfitted for the high pressures which Mr. Fairlie and other locomotive engineers are using with such good results. MM. Meyer have stated that they could, if they chose, use the double boiler; but although they could no doubt do so, the adoption of that boiler would necessitate a most material alteration of their plans, and a very close approach to those of Mr. Fairlie. In fact if the engravings of the engine at present under notice be examined, the difficulty which MM. Meyer would have in successfully adopting the double boiler will be strikingly apparent. Mr. Fairlie constructs his bogies with the cylinders at the outer ends, and he places the two bogies sufficiently far apart to allow of the firebox descending between them. He can thus obtain any desired firegrate area without difficulty, and any reasonable depth of firebox without unduly raising the boiler. MM. Meyer, on the other hand, arrange the cylinders at the inner ends of their bogies, and couple the latter close together, the firebox having thus to be placed entirely above one of them. To keep the total height of the boiler within reasonable limits a very shallow fire-box is thus rendered necessary, and although in the engine exhibited at Vienna something was gained by adopting a sloping grate, and cutting away the trailing bogie frame where it could be spared, even in that case a depth of only about eight inches was obtained below the bottom row of tubes. It is worthy of notice, also, that to obtain even this result the engine shown at Vienna was made without an ash-pan, so that not only was there no such means of regulating the fire as an ash-pan damper affords, but the axle boxes, &c. of the trailing bogie were all exposed to the heat and the falling ashes. It would be possible to remedy the last-mentioned inconvenience to some extent by a kind of screen fixed to the bogie frame, but such a screen would not serve the purpose of an ash-pan proper, and it would render the fire-grate accessible with difficulty. Altogether, we cannot but regard MM. Meyer's arrangement as most objectionable. If now MM. Meyer adopted the double boiler they would be even more hampered by the nature of their general design. In such a case the firebox would be situated directly over the connexions between the two bogies, and while there would still be the deficiency in depth of firebox, the transverse stays required to give support to the cylinders would render the grate almost inaccessible.

Another point of MM. Meyer's designs which we regard as objectionable is the mode of carrying the boiler. Mr. Fairlie, as is well known, connects his two bogies by a carrier frame, which takes all the strains due to traction, and forms a kind of cradle in which the boiler rests, so that the latter is efficiently supported, and is at the same time left quite free for expansion and contraction, and relieved of all strain due to the working of the engine. MM. Meyer, on the other hand, support their boiler on three points, one situated under the barrel of the boiler near the smokebox, and the others arranged one under each side of the firebox, the bearing in these latter cases being taken on slides at the tops of the frames of the trailing bogie. In the engine shown at Vienna the distance longitudinally between the front and hind supports was 20 ft. $\frac{3}{4}$ in., the boiler being entirely unsupported over this great span. Nor was this all. In their original engine the "Avenir" MM. Meyer placed the tanks and coal bunkers on the bogie frames, and this arrangement had many defects, and gave rise to grave inconvenience. In the engine shown at Vienna this arrangement was abandoned, but, instead of it, the tanks and coal bunkers were attached to the boiler by plate-iron brackets. In addition to its own weight, and the weight of the five tons of water it contained, the boiler had thus to support over the span above mentioned the weight of the tanks and coal boxes, and their contents, this amounting to at least 12 tons or so. It is impossible to regard this as an arrangement compatible with the economical maintenance of the boiler, while the great load made to rest upon the side frames of the trailing bogie tends to materially limit the freedom of motion of that bogie, a tendency which is increased by the fact that the slides between which the motion takes place are situated so close to the fire-grate that it must be difficult to keep them cool and well lubricated. The mode adopted by Mr. Fairlie, of transmitting the tractive power direct from one bogie centre to the other through the carrier frame, is also, in our opinion, vastly superior to the mode of coupling the bogies

adopted by MM. Meyer. Of some other defects of MM. Meyer's plans we need not speak here, but we have said enough to show that there are most material differences between their plans and Mr. Fairlie's, and we think that it will also be allowed that, although Mr. Fairlie may not have been the first proposer of locomotives with two steam bogies, yet that to him is undoubtedly due the credit of having produced that arrangement of double-bogie engine which has successfully stood the test of practical experience. This being the case, and bearing in mind the important position which the double-bogie system appears destined to occupy in future locomotive practice, it is, we think, a matter for sincere regret that a Fairlie engine was not exhibited at Vienna.

Germany.

Germany was, as might have been expected, a large exhibitor of locomotives at Vienna. Altogether 18 German locomotives were shown—all the leading makers being represented—and the exhibition was an exceedingly fine one. In describing these engines we shall speak first of those intended for working passenger traffic, next of those for goods service, and finally of the tank engines.

Express Locomotive for the Railways of Upper Italy, by the Société Alsacienne de Constructions Mécanique (formerly Andre Kœchlin and Co.), Mulhouse.—This engine was exhibited, not in the machinery hall with the other German locomotives, but in an annexé erected in one of the garden courts on the southern side of the Industry Palace, this building being a full-sized model of the Bardonneche entrance of the Mont Cenis Tunnel. The annexé thus formed contained, besides a number of geological specimens and examples of the boring machines, &c. used in the construction of the work, a portion of a train such as is used in working the passenger traffic through the tunnel. Of the train itself—in which the chief point of interest is the mode of lighting—we shall speak in the proper section, our object in the present instance being to describe the engine to which the train was attached.

As will be seen from the engravings (Figs. 3 and 4, Plate XCI., and Plates XCII. and XCIII.), this engine, which was constructed by the Société Alsacienne de Constructions Mécanique (formerly Andre Kœchlin and Co.), of Mulhouse, has four coupled wheels, and outside cylinders and valve gear. The cylinders are 16·93 in. in diameter with 24·41 in. stroke, and the coupled wheels have a diameter of 6 ft. 7·13 in., so that the engine is adopted for working fast traffic. The construction of the engine is so clearly shown by the various views that it will be unnecessary for us to enter into any lengthy description.

The frames, which are inside, are very deep, and at the sides of the firebox they are carried down so as to form brackets for supporting the compensating levers. The frames are well connected by cross stays, particularly at the leading end, where the mode of fixing and supporting the cylinders is particularly well carried out, and altogether the locomotive under notice was one of the best framed engines shown at the exhibition. It will be noticed, by-the-bye, that the frames and frame stays are rivetted up instead of being bolted together, as is the usual English practice. The leading buffer beam is a box girder, formed of two plates and two channel irons, as shown in the longitudinal section. The driving and trailing springs are arranged below the axles, and connected by compensating beams, as shown, the spring hangers connecting the springs to the axle boxes being dovetailed into the latter, as shown in the longitudinal section, so that the pull of the springs does not come upon the pins passed through the axle box, these pins merely preventing side movement. The axle boxes are of wrought iron, and the keeps of cast iron, while the guides for the axle boxes of the coupled wheels are fitted with adjusting wedges. The leading springs are placed above the axle boxes, and the leading axle has a lateral play in the boxes of five millimetres (¼ in.) each way.

The connecting rods, coupling rods, and valve motions are of steel, and it will be noticed that the large ends of the connecting rods, and one end of each coupling rod are open forks, the cotters pressing against blocks, which

are pierced to allow the arms of the forks to pass through them. The piston rods are enlarged where they enter the crossheads, the glands being made in halves. The valve motion is of the stationary link type, and the slide valves, which are of brass, and of Trick's pattern, lay obliquely over the cylinders, as shown by the side elevation and by the transverse section, Fig. 4, Plate XCI. The reversing is effected by screw gear, arranged as shown in the side elevation, Plate XCII.

The boiler has a high firebox casing, carrying a very large dome, as shown, this dome containing the regulator, which is a double gridiron valve arranged to give first a small and then the large opening. A manhole is provided on the first ring of the barrel, the cover of this manhole carrying a valve which closes an opening through which the boiler can be filled. The inside firebox is of copper, and its crown is strengthened by transverse roof stays, the ends of which rest upon heavy angle irons rivetted to the sides of the firebox casing, as shown in the transverse section, Fig. 4, Plate XCI. This view, and the longitudinal section, Plate XCIII., will also fully explain the arrangement of the transverse sling and other stays.

The firegrate is for the greater part of its length very steeply inclined, a portion at the front end is, however, placed nearly horizontally, and is made to drop, as shown. The arrangement of grate is, in fact, similar to that introduced by Mr. Cudworth on the South-eastern Railway. The boiler is fed by a pair of injectors, and a pipe is provided, as shown in the side elevation, for delivering a portion of the feed into the smokebox to put out any burning cinders. The smokebox is also provided with a spark arrester, consisting of a grating fixed across it just below the mouth of the blast pipe. The steam jet, it will be noticed, is arranged to discharge in the centre of the blast nozzle. The engine is fitted with a sand-box having the sand valves worked from the foot-plate, and it is also provided with Le Chatelier's counter-pressure brake apparatus.

The workmanship and general finish of the engine we have just described were excellent, and as will be seen from our engravings the details of the design are well worked out. Our engravings are fully marked with the metrical dimensions, but for convenience we subjoin a list of the leading particulars in English measures :

	ft.	in.
Cylinders:		
Diameter	1	4·93
Stroke	2	0·41
Distance apart from centre to centre	6	2·8
Working gear:		
Diameter of piston rods	0	2·52
Length of connecting rods	6	4·97
Diameter of large end bearings	0	4·72
Length of large end bearings	0	4·72
Coupling rod bearings on driving crank pin, diameter	0	4·33
Coupling rod bearings on driving crank pin, length	0	3·54
Coupling rod bearings on trailing crank pin, length and diameter	0	3·54
Travel of eccentrics	0	4·72
Angular advance of eccentrics, 30°		
Wheels and axles:		
Diameter of coupled wheels	6	7·13
„ leading „	4	5·7
Distance between centres of leading and driving wheels	6	6·74
Distance between centres of coupled wheels	8	8·33
Total wheel base	15	3·07
Bearings of leading axle; diameter	0	6·7
Bearings of leading axle; length	0	9·84
Bearings of coupled axles; diameter	0	7·28
Bearings of coupled axles; length	0	9·84

	ft.	in.
Wheels and axles—cont.		
Centres of bearings of all axles	3	9·7
Distance of centre of driving axle from front of firebox casing	2	3·16
Frames:		
Total length over buffer beams	26	6½
Transverse distance between frames	4	0·42
Thickness of frames	0	1·1
Total width of engine over footplate	8	6·4
Boiler:		
Diameter of barrel inside largest plate	4	0·8
Length of firebox casing	7	8·9
Width „ „ at widest part	4	2·9
Width of firebox casing at bottom	3	10·5
Height of top above centre line of boiler	3	2·6
Depth below centre line of boiler at front	4	7·1
Depth below centre line of boiler at back	2	3
Length of inside firebox at top (inside)	6	10·7
Width inside at widest part	3	6·7
„ „ bottom	3	2·7
Height at front end	5	4·9
„ back „	3	0·8
Diameter of dome	2	7·5
Height of dome above crown of firebox casing	3	3·37
Number of tubes	191	

Boiler—cont.	ft.	in.
Diameter of tubes outside	0	1·97
„ „ inside	0	1·77
Length between tube plates	11	5·8
Diameter of chimney at bottom	1	3·75
Diameter of chimney at top	1	5·32
Height of top of chimney above rails	13	9·4
Height of centre line of boiler above rails	6	6·74
Thickness of barrel plates	0	0·53
„ smokebox tube plate	0	0·79
Thickness of dome plates	0	0·39
„ firebox plates (copper)	0	0·63
Thickness of firebox tube plate	0	0·98

Heating surface:	square feet
Firebox	97·2
Tubes, external	1,132·
„ internal	1,017·

Heating surface—cont.	square feet
Total with external tube surface	1,229·2
Total with internal tube surface	1,114·2
Firegrate area	23·73
	cubic feet.
Water capacity of boiler with water level ¼ in. above crown of firebox	101·9
Steam capacity of boiler with water level ¼ in. above crown of firebox	80·2
Total capacity of boiler	182·1
Pressure of steam in boiler, 132·3 lb. per square inch.	
	tons
Weight of engine empty	33·95
Weight in working order:	tons.
On leading wheels	12·01
„ driving „	13·03
„ trailing „	12·30
Total	37·34

Passenger Locomotive for the Berlin-Potsdam-Magdeburg Railway by A. Borsig, Berlin.—Borsig, of Berlin, who exhibited his 2000th locomotive at the Paris Exhibition of 1867, sent his 3031st engine to Vienna, this engine being one constructed by him for the Berlin-Potsdam-Magdeburg Railway. As will be seen by the illustrations (Plates XCIV. and XCV.) the engine has six wheels—the driving andtrailing wheels being coupled—outside cylinders, outside frames, and inside valve gear, the arrangement being that known as Hall's system. The cylinders are 17 in. diameter by 22 in. stroke, and are placed 7 ft. 7⅝ in. from centre to centre. They are well fixed to the frames, as shown by the half transverse section through the smokebox, on Plate XCV., and they are fitted with balanced slide valves, as will be seen from the sectional plan, Plate XCIV.

The coupled wheels are 6 ft. 4 ⅜ in. in diameter, and are 7 ft. 8⅝ in. apart from centre to centre. The leading wheels are 4 ft. in diameter, and the distance between the centres of the leading and driving axles is 6 ft. 8⅝ in., thus making the total wheel base 14 ft. 5½ in. The springs are all arranged above the axles, and those for the coupled axles are connected by compensating beams as shown, the brackets for holding the centres of these levers being neatly arranged, as shown in the transverse section through the firebox. As the engine has outside frames the coupled axles have, of course, outside cranks, those on the driving axle being arranged so that the bearings are formed on their bosses. In the case of the trailing axle this arrangement is not necessary, as the coupling rods being outside the connecting rods room is left for the bosses of the trailing cranks outside the axle bearings. The axle box guides for the coupled wheels are fitted with adjusting wedges.

The valve gear is of the Allan straight link type, and it and all the details of the motion are very well worked out. The reversing is effected by a screw. The connecting rods and coupling rods are grooved or recessed at the sides, the shape of the recesses in cross section being a segment of a circle. This section, although it does not lighten the rods so much as grooves of a rectangular section and equal width and depth, has the advantage over the latter that it enables the rods to be more easily kept clean. The pattern of the connecting and coupling rod ends is particularly neat, the brasses being set up by wedges and screws. The crosshead, too, is of very neat design, and the guide bars are substantial. The crosshead blocks are fitted with brass liners or wearing pieces, as in the case of most German locomotives. The piston rods are enlarged in the pistons and crossheads, the glands being made in halves to allow of this. The pistons are of a very light section, as shown, and are made of wrought iron.

The frames are deep, and are each formed of a single plate 1·18 in. thick, while their distance apart is 5 ft. 11·4 in. The two frames are, as will be seen, well connected by transverse stays, and the squareness of the whole is well insured by the strong horizontal plate stays introduced at the leading

end above and below the cylinders, these plates extending back from the leading buffer beam to the hind end of the cylinders. The manner in which the boiler is carried is clearly shown by the transverse sections (Plate XCV.) and by the plan and sectional plan. The supports at the firebox end are of course arranged so as to admit of the free expansion and contraction of the boiler.

The boiler barrel is 4 ft. $1\frac{3}{8}$ in. in diameter inside the largest plate, and its centre is 6 ft. $3\frac{3}{8}$ in. above rail level. It contains 169 tubes 1·97 in. in diameter outside, 1·77 in. inside, and 12 ft. $1\frac{7}{8}$ in. long between tube plates. The smokebox tube plate is of iron 1 in. thick, while the rest of the barrel is of steel plates 0·51 in. thick. The firebox casing is 6 ft. $6\frac{3}{4}$ in. long, and has the top stayed on Herr Becker's plan, of which we shall speak more fully when treating of the Austrian locomotives. A modification has, however, been made by the introduction of transverse stays above the firebox, these stays being secured to arched diagonal angle irons, arranged as shown in the transverse section through the firebox. The plates of the firebox casing are of iron, and are 0·59 in. thick.

The inside firebox is of copper, and is 5 ft. $8\frac{1}{8}$ in. long at the top, and 5 ft. $11\frac{5}{8}$ in. at the bottom, while its widths are 3 ft. $7\frac{3}{8}$ in. and 3 ft. $8\frac{1}{2}$ in. at the top and bottom respectively. The grate is placed at a very steep inclination, so as to enable the trailing axle to be got in beneath it, and thus the height of the firebox crown above the bars is 4 ft. 4 in. at the front, but only 2 ft. $1\frac{1}{8}$ in. at the hind end. The side and back plates of the firebox, and the lower part of the tube plate are 0·59 in. thick, while the upper part of the tube plate is 1·02 in. thick, and the crown plate 0·79 in. thick. The firebox heating surface is 76·6 square feet, while the tubes expose 952·3 square feet of internal, or 1,059·5 square feet of external surface. The total surface, with internal tube surface, is thus 1028·9 square feet, or with external tube surface, 1,136·1 square feet. The horizontal projection of the firegrate area is 22·13 square feet. The firedoor is of the "Midland" or sliding pattern, and the details of its arrangement, as, indeed, of all the boiler fittings, are extremely well worked out. The boiler is fed by two injectors, arranged below the footplate as shown.

The footplate is protected by a comfortable cab fitted with windows, which turn on top and bottom centres, a neatly arranged catch being provided for fixing them at any desired angle of opening. The workmanship of the locomotive exhibited at Vienna was of the highest class, the brasswork and coppersmiths' work, in particular, being of unusual excellence, while the whole engine was distinguished by that attention to matters of detail and finish which especially characterises the productions of experienced locomotive builders. Altogether the engine we have described is undoubtedly one which will do good work with fast trains, although the arrangement with outside frames and cranks certainly leads to the employment of greater weight than would be necessary for the production of an equally powerful engine with inside frames and with the crank pins fixed in the wheel bosses in the ordinary way. We may add, in conclusion, that the weight of the engine in working order is 36·1 tons, this weight being distributed as follows:—On leading wheels, 12 tons; on driving wheels, 12·1 tons; and on trailing wheels, 12 tons.

Passenger Locomotive for the Carl Ludwigs-bahn, by Emil Kessler, of Esslingen.—The next engine we have to notice is the "Dnieper," a passenger engine constructed by Herr Emil Kessler, of Esslingen, for fast passenger service on the Carl Ludwigs-bahn. The engine, we may add, is one of an order for 12 in course of execution during 1873 by Herr Kessler, for the Carl Ludwigs-bahn, on which railway five similar engines have been at work since August 1872, these having been employed in working the service between Cracow and Lemberg, a service which Herr Lushku, the chief inspector of the line, states they perform most satisfactorily.

As will be seen from the engravings (Plates XCVI. and XCVII.) the engine has six wheels, the leading and driving pairs being coupled. The cylinders are outside, and the valve motion, which is of the straight-link type, inside. The valves are of the Haswell or Trick pattern, and their dimensions, as well as the general dimensions of the valve gear, are given in the outline diagram,

Fig. 7, Plate XCVII. The large diameter of the leading wheels, namely, 6 ft. 3 in., necessitates a great length of guide bars; but in the case of the "Dnieper," these bars have been made very heavy, and they are, moreover, stayed together, as shown in the side elevation, so as to secure rigidity. The connecting and coupling rods, and, in fact, all the details of the motion are of exceedingly neat design and good proportions; while the connecting and coupling rods and piston rods are made of steel, as are also the tyres.

The frames are inside, and are well braced together by cross stays, as shown in the plan. The axle-box guides for the coupled axles are fitted with adjusting wedges, and the leading and trailing springs are connected by compensating beams, as shown. We may direct attention here to the position of the sand box, which is unusual, the box being situated under the barrel of the boiler, and fixed to one of the transverse frame stays, as shown in the longitudinal section, sectional plan, and half-transverse section, Plates XCVI. and XCVII. From this latter view, which shows the shape of the box clearly, it will be seen that the sand can be poured in through branches or spouts which extend upwards and laterally, and end above the footplate. The box is furnished with sand valves worked from the footplate, the sand being delivered just in front of the driving wheels.

The boiler, which is made of iron plates from Dillingen, has a raised fire-box casing, as shown in the various views. The inside firebox is of copper and the tubes of brass, these latter being made by Heckmann, of Berlin. The fire-box is large, being intended for burning soft coal, and it has a slightly sloping grate. The roof is supported by ordinary girder roof stays, these being necessarily, however, from their long span very heavy. The back plate of the fire-box casing is supported by gusset stays, and the smokebox tube plate by a strong horizontal plate stay fixed just above the tubes. The shell plates are 14 millimetres (0·55 in.), the dome plates 12 millimetres (0·472 in.), and the smoke-box tube plate 21 millimetres (0·827 in.) thick; while the copper plates of the firebox are 15 millimetres (0·59 in.) thick, with the exception of the upper part of the tube plate, which has a thickness of 24 millimetres (0·94 in). The boiler, which is worked at a pressure of eight atmosphere effective, or about 118 lb. per square inch., is fed by two Schau's injectors arranged below the footplate, and the water is delivered into the barrel of the boiler near the firebox, the delivery pipes being furnished inside the barrel with bends which direct the stream of water forward. The exhaust pipe is furnished with a variable blast nozzle, and the chimney is provided with a spark-catcher, as shown. The general fittings of the boiler are very neat and well finished, and we may mention that the handles of the upper and lower cocks of the gauge glass fittings are coupled, so that they may be opened and shut together. This arrangement is very handy in the event of the gauge glass breaking, and it is very generally used on the Continent, although we have not seen it adopted in this country.

The principal dimensions of the engine we have been describing are :—

	ft.	in.
Diameter of cylinders	1	3⅝
Stroke	2	0⅝
Transverse distance between centres of cylinders	6	7⅝
Diameter of coupled wheels	6	3
„ trailing „	3	3½
Distance between centres of coupled wheels	6	7⅝
Distance between centres of driving and trailing wheels	6	10½
Total wheel base	13	5½
Diameter of boiler inside largest plate	4	0⅜
Length of firebox, inside at bottom	5	5
Width of firebox, inside, at bottom	2	11⅛
Number of tubes - 155		
Diameter of tubes, outside	0	2⅜

	ft.	in.
Length o tubes between tube plates	12	10¼
Heating surface:	sqr. ft.	
Firebox	85·2	
Tubes, outside	1,093·3	
	1,178·5	
	sqr. ft.	
Firegrate area	16	
	tons.	
Weight of engine, empty	28¾	
„ „ in working order;		
On leading wheels	12	
„ driving „	12½	
„ trailing „	7½	
Total	32	

The tender which we illustrate in Figs. 1, 2, and 3, Plate XCVII., but which we should state was not shown at the Vienna Exhibition, is of the normal pattern

used on the Carl Ludwigs-bahn. It is, as will be seen, a six-wheeled tender and is arranged so that the fuel is carried on the top of the tank, while there is an external tool-box at the trailing end. The general design is very neat, and the details will be readily understood from the engravings without special description. The tender carries 1,980 gallons of water and about $5\frac{1}{4}$ tons of fuel, and its weight, empty, is 9·56 tons, or about 23·8 tons loaded. In conclusion, we should state that the workmanship of the engine we have been describing was excellent in every respect, and all the details of the design are well worked out.

Passenger Locomotive for the Bergisch-Märkische Railway, by the Stettiner-Maschinenbau-Actien-Gesellshaft "Vulcan."—Continuing our survey of the locomotives in the German section, we have next to notice a four-coupled passenger engine, constructed by the Stettiner-Maschinenbau-Actien-Gesellshaft "Vulcan," for the Bergisch-Märkische Railway, this locomotive being one of 11 constructed by the firm just mentioned for working the passenger traffic of that railway through the valley of the Upper Ruhr. The engine was built from the designs of Herr Stambke, the locomotive superintendent of the line, and its general arrangement will be understood from the views on Plate XCVIII. From these views it will be seen that the engine has the driving and trailing wheels coupled, and a two-wheeled Bissell truck under the leading end, this truck being provided to facilitate the passage of the numerous curves, many of them of 300 metres (980 ft.) radius, to be found on the line on which the engine is to work. The coupled wheels are 5 ft. in diameter, and the truck wheels 3 ft. 2 in. in diameter, while the total wheel base is 14 ft. 5 in., the rigid wheel base being, however, diminished by the employment of the truck to 8 ft. $6\frac{3}{8}$ in.

The truck has a lateral play of 50 millimetres (1·9 in.), and the inclines which govern its movements are so proportioned that the thrust necessary to force the truck over does not exceed a ton. The constructive details of the truck are shown by Figs. 3, 4, and 5, Plate XCVIII. From these views it will be seen that the bearing pieces resting on the upper inclines of the Bissell arrangement are carried by a pair of cross stays fixed to the frames, there being no bogie pin fixed to the boiler, as in many engines of a similar type. The back centre of the bogie, or that on which the radius bar turns, is also carried by a pair of cross stays fixed just in front of the driving axle. The leading spring is placed transversely, and the whole of the details of the bogie are well worked out; the efficient arrangement of the cross stays for the main frame being materially facilitated by the fact that the engine has outside valve gear.

The trailing axle is placed well under the fire-box, which is cut away to accommodate it, and the springs of the driving and trailing axles are connected by compensating beams, these beams being prolonged past the points of attachment of the spring links, and their ends being arranged to work between guide pieces so as to prevent lateral play. The provision of these guide pieces, however, seems to us to be an unnecessary refinement.

The cylinders, which are outside, are $16\frac{1}{2}$ in. in diameter, with 1 ft. $11\frac{5}{8}$ in. stroke, and they are placed rather wide apart to allow of the necessary lateral play of the leading wheels, the connecting rods taking hold of the crank pins outside the coupling rods. The valve chests are on the top of the cylinders, the valve faces being inclined, while the valve gear, which is outside, is of the Allan straight link type, a type which is now being very extensively adopted by German locomotive engineers. The slide valves are cast iron, and are port valves on Trick's system.

The dimensions being as we have stated, the engine is capable of exerting a pull of

$$\frac{16{\cdot}5^2 \times 23{\cdot}625}{60} = \frac{272{\cdot}25 \times 23{\cdot}625}{60} = 107{\cdot}2 \text{ lb.}$$

for each pound of effective pressure per square inch on the pistons, and as the boiler pressure is 10 atmospheres effective, or 147 lb. per square inch, a pull of between 11,000 and 12,000 lb. could probably be exerted by the pistons at moderate speeds. The total weight upon the coupled wheels, however, namely, $24\frac{3}{4}$ tons, would only permit of this maximum pull being utilised under very favourable circumstances. It will be seen from this that the engine has ample cylinder power, and we may add that it has been

designed to work trains weighing (exclusive of engine and tender) 140 tons up gradients of 1 in 72, and round curves of 300 metres radius at a speed of 50 kilometres, or 31 miles per hour.

The boiler has a flush-topped fire-box casing, the crown being stayed direct to the crown of the fire-box by iron stay bolts, as shown. The boiler shell is double rivetted throughout, and is made of plates 14 millimetres (0·55 in.) thick, the copper plates of the firebox being 0·629 in. thick. The boiler is fixed to the frames at the front ends only, it being merely supported at the other points. The barrel, the centre line of which is 6 ft. $4\frac{1}{4}$ in. above rail level, is 4 ft. $1\frac{9}{16}$ in. in diameter inside the middle ring of plates, and contains 188 tubes $1\frac{3}{16}$ in. diameter outside, and 12 ft. 1 in. long between tube plates, these tubes giving an external heating surface of 1,079 square feet, or an internal surface of $956\frac{3}{4}$ square feet. The fire-box surface is 75·2 square feet, thus making with the internal tube surface a total of 1,031·95 square feet, or if the external tube surface be taken, a total of 1,154·2 square feet. The fire grate area is 17·7 square feet, the grate for the main portion of its length being steeply inclined, as shown in the outline section (Fig. 2, Plate XCVIII.).

The smokebox tube plate and back plate of the firebox casing are, as will be seen, stiffened not only by gusset stays, but by bar stays placed low down—some being below the centre line of the boiler—and rivetted to the barrel of the boiler, as shown. This placing of diagonal stays so low down is unusual, and is, we consider, unnecessary. The boiler is furnished with a very large dome, as is the case with most German locomotives, this dome containing the regulator, which is of the ordinary gridiron pattern. The boiler is fed by a pair of Schau's injectors, with fixed nozzles, arranged below the footplate, and it carries three safety valves, namely, a pair of Ramsbottom's valves and an ordinary valve at the top of the dome, this valve having its spring balance fitted with a bell-crank lever on Meggenhofen's system — an arrangement which is much used on German locomotives, and the effect of which is to reduce the pressure on the valve as the latter rises. The chimney is constructed on what is known in Germany as Krüssmann's system, its form, however, being that introduced many years ago by Mr. Robert Sinclair, when locomotive superintendent of the Caledonian Railway, and now largely used both at home and on the Continent, not only for locomotives, but for traction engines and portable boilers of various types. The least diameter of the chimney in the case of the engine we are describing is 13 in.

The footplate is protected by a neat cab, and the general finish of the engine is very good, a somewhat exceptional appearance being imparted to it by the plentiful employment for fittings, ornamental mouldings, &c., of a kind of white brass somewhat resembling German silver. This metal has a less glaring effect than brass certainly, but the appearance is somewhat cold; the effect might, however, we think, have been improved by the selection of a colour which would blend better with that of the metal than that which happens to have been chosen in painting the engine of which we are speaking. The engine weighs in working order, 35 tons, of which $10\frac{1}{4}$ tons rest on the leading wheels, $12\frac{3}{4}$ tons on the driving wheels, and 12 tons on the trailing wheels. The weight is thus well distributed, and the engine is altogether well-built and of a very serviceable type.

Express Passenger Locomotive for the Hanoverian State Railway, by the Hannoversche Maschinenbau Actien-Gesellschaft, (formerly G. Egestorff).—Adjoining the locomotive above noticed we found two engines from the Hannoversche Maschinenbau Actien-Gesellschaft (formerly Georg Egestorff), of Linden, Hanover, a firm which, during the year 1871, turned out 200 locomotives. One of the engines exhibited is named the "Bismark," and is intended for express passenger service. It is, as will be seen from the view on Plate XCIX., a six-wheeled engine, having driving and trailing wheels 6ft. $\frac{3}{4}$ in. in diameter and coupled, and leading wheels 3 ft. $6\frac{3}{4}$ in. in diameter. The distance between centres of leading and driving wheels is 6 ft. and that between centres of coupled wheels 8 ft., thus making the total wheel base 14 ft.; the springs of the leading and driving wheels are connected by compensating beams, while at the trailing end of the engine there is a simple spring placed transversely.

The cylinders are outside, and are 16½ in. in diameter, with 22 in. stroke, while the valve gear is inside, and is of the straight link type, and provided with screw reversing gear. The boiler, which is worked at a pressure of 10 atmospheres effective, or 147 lb. per square inch, has a Belpaire fire-box giving 81·8 square feet of heating surface, and the barrel contains 190 tubes 1·89 in. in diameter, outside, and 11 ft. 7⅛ in. long between tube plates, these tubes giving an external surface of 1,103 and an internal surface of 971 square feet. The total heating surface is thus 1,184·8 square feet if the external tube surface be taken, or 1,052·8 square feet taking the internal tube surface, while the fire-grate area is 21 square feet. The engine weighs 30·8 tons empty, and probably about 35 tons in working order. The distribution of this weight we have, however, not been able to ascertain.

A point of detail about this engine worth notice—although scarcely one to be commended—is the arrangement of gear for delivering the sand from the sand box, the latter being on the top of the boiler. The sand is delivered by a worm, the shaft of which passes through the side of the sand box, and carries at its outer end a bevel wheel. This wheel gears into a similar wheel at the upper end of a short inclined shaft, the lower end of which carries another bevel wheel gearing into a similar wheel on a shaft which runs along the side of the boiler, and forms the handrail. This shaft is turned by the driver, and the motion is thus communicated to the worm in the sand box through the intervention of four bevel wheels. We fancy that the same end might have been achieved with a few less parts. The general finish of the "Bismark" is excellent, and the engine is one which has attracted much attention at the Exhibition.

Goods Locomotive for the Railways of Alsace and Lorraine by the Hannoversche Maschinenbau Actien Gesellschaft (formerly G. Egestorff).—The other locomotive from the same makers is the "Linden," this being a six-coupled outside cylinder goods engine with inside frames, and evidently intended for heavy work. As will be seen from the side elevation (Plate XCIX.), the driving and trailing axle-boxes are connected by compensating beams, a single spring on each side of the engine connected to the centres of beams serving for both axles. This is an arrangement adopted on several other locomotives exhibited at Vienna, and it undoubtedly has its conveniences, although when a long engine is mounted on a short wheel base, as is generally the case when this arrangement is used, we should prefer dispensing with the compensating beams altogether, as they practically still further reduce the wheel base as far as the power of checking longitudinal oscillations or pitching motion is concerned.

The cylinders of the "Linden" are, as we have said, outside while the valve gear, which is of the Stephenson type, is inside, and is fitted with screw reversing gear. A noticeable feature in connexion with this engine is the extreme thinness of the coupling rod ends, and the shortness of the crank-pin bearings, a peculiarity which also distinguishes Messrs. Henschel and Son's engine, of which we shall speak hereafter. The engine now under notice has a Belpaire firebox. A little special detail in this engine is the mode adopted of stowing the tools, such as hammers, spanners, &c., these being arranged in a very shallow cupboard formed inside the handrail plate on one side. A tool box thus arranged takes up very little room, while the tools being held in suitable racks are very readily accessible. The principal dimensions of the "Linden" are as follows:—

	ft.	in.
Diameter of cylinders	1	6·54
Stroke	2	0
Diameter of wheels	4	3¼
Distance between centres of leading and driving wheels	5	8
Distance between centres of the driving and trailing wheels	4	9⅝
Total wheel base	10	5⅝
Inside diameter of boiler	4	7⅛
Height of centre of boiler above rails	6	5
Number of tubes	218	
Diameter " outside	0	1·81
Length " between tube plates	11	6⅛

	ft.	in.
Length of firebox inside	4	6
Width " "	3	5

Heating surface:	sq. ft.
Firebox	86·1
Tubes (outside)	1,447·75
" (inside)	1,275·5
Total with external tube surface	1,533·85
Total with internal tube surface	1,361·6
Firegrate area	15·81
Pressure of steam	132·3 lb. per sq. in.
Weight of engine empty	31½ tons.

Like the "Bismark" the "Linden" is a very creditable piece of work, and although it is of a type which appears to us calculated to be very trying to the permanent way, it is nevertheless one extensively used on the Continent where the speeds for goods trains are lower than with us, and where the effect of the short wheel base is consequently less severely felt than it would be on English lines.

Goods Locomotive for the Kaiserin Elizabeth Railway of Austria, by the Sächsische Maschinenfabrik zu Chemnitz (formerly R. Hartmann).—The next locomotive exhibited in the German section, which we have to notice here, is a heavy eight-coupled goods engine for the Kaiserin Elizabeth Railway of Austria, constructed by the Sächsische Maschinenfabrik zu Chemnitz (formerly Richard Hartmann). This engine has been built from designs furnished by the railway company, so that it does not represent the regular practice of the makers. It is, as shown by the engravings on Plates XCIX. and C., an eight-coupled engine, the wheels being 3 ft. 7½ in. in diameter, and arranged with a wheel base of 11 ft. 9 in. The trailing axle is, however, allowed lateral play, so that the rigid wheel base is reduced. The axles are all situated under the barrel of the boiler, as is usual on the heavy Austrian engines, and the driving and trailing axle boxes are connected by compensating beams, a single spring on each side serving for the two axles. The arrangement of these springs is shown by the longitudinal section and plan, from which views it will also be seen that the front ends of the two leading springs are connected by a transverse compensating beam. The axle box guides are all fitted with adjusting wedges. The frames are made double from the leading buffer-beam to the front of the firebox; but from that point they each consist of a single plate, this plate being bent outwards to allow of an increased width of firebox, as shown in the plan. The frames are well connected laterally by cross stays, these being arranged to support the barrel of the boiler at four points, as shown, but the means provided for insuring the squareness of the frames by horizontal plate stays appears to us somewhat insufficient. It will be seen, on reference to the longitudinal section and transverse section through smokebox, that the boiler is carried quite clear of the main frames, except at the firebox end, it elsewhere resting only on the transverse frame stays.

The cylinders, which are outside, are 17⅜ in. in diameter, with 22⅞ in. stroke, and the piston rods are carried through the front cylinder covers, the glands being each provided with a protecting casing which covers the rod. The connecting rods are of I-section, and the trailing length of each set of coupling rods is united to the next length by two pins in the manner of which we shall have more to say when speaking of the Austrian locomotives. One of the pins used, passes through an oval hole, so that the rods have a certain degree of flexibility vertically, while the long fork and the two pins give rigidity laterally. The crank pins of the trailing wheels are simply made long enough to allow of the side play of that axle taking place without affecting the coupling rods. The valve motion is inside, and is of the stationary link type, the valve rods being made as shown in the longitudinal section to clear the leading axle.

The boiler is very large, and has a firebox of the Belpaire pattern. The transverse staying of the upper part of the firebox casing, however, instead of being effected by stay bolts screwed into both plates as usual, is accomplished by means of transverse stays connected by pins to wide horizontal plates, which are rivetted by means of angle irons to the side plates of the casing. The back plate of the firebox casing and the smokebox tube plate are supported by longitudinal stays, arranged as shown. The boiler is provided with a large dome at the leading end, this dome containing the regulator, which is of the ordinary grid-iron pattern. The steam pipes are led from the dome to the cylinders outside the smokebox. The boiler exposes altogether 1624·8 square feet of heating surface, of which 1,523·4 square feet are tube surface, and 101·4 square feet firebox surface. The fire-grate area is 18·8 square feet, and the pressure of steam 9½ atmospheres effective, or say, 140 lb. per square inch. The blast nozzle is variable, its area of opening being adjustable from 6 to 18 German square inches, or from 6·35 to 19 square inches English, an index showing the extent of opening given. The chimney is, as will be seen, fitted with a spark arrester, and a hopper with sliding plate is provided for discharging the ashes from the smokebox.

The weight of the engine in working order is 42·35 tons, stated to be distributed as follows:—On leading axle, 10·6 tons; on second axle, 10·6 tons; on driving axle 10·5 tons; and on trailing axle 10·65 tons. We cannot but think, however, that some mistake must have been made in taking these weights, as with the equal armed compensating levers connecting the driving and trailing axle boxes the load on the driving wheels would be the greater to the extent of the weight of the eccentrics and part of the weights of the connecting and eccentric rods. In conclusion, we should state that the general finish of the engine we have just been describing is of the highest class, and fully supports the reputation the builders have already earned for good workmanship.

Goods Locomotive for the Bavarian State Railways, by T. A. Maffei of Munich.—Herr T. A. Maffei, of Munich showed in the German section of the Machinery Hall, a very highly finished goods engine intended for the Bavarian State Railways. This engine was the 900th locomotive turned out from Herr Maffei's works, and it belongs to a class of which that maker has constructed some 250 engines, these locomotives having been furnished to the Bavarian State Railway, the Eastern Railway of Bavaria, the lines of the Palatinate, the Western Railway of Bavaria, and the Crown-Prince Rudolph's Railway.

Referring to the engravings on Plate CI., it will be seen that the engine is constructed on the Hall system, with outside cylinders, outside frames, and with outside cranks having the axle bearings formed on their bosses. The cylinders, which are placed in a slightly inclined position, are 19·13 in. in diameter with 26 in. stroke, while the piston rods are extended through the front covers to afford support to the pistons. The slide valves are of the Haswell or Trick pattern, giving a double opening for admission, while the valve gear is of the Allan straight link type and is placed inside the wheels. The tyres, axles, cranks, connecting and coupling rods, piston rods, and guide bars are of steel, and all the working gear is well proportioned and very highly finished. The guide bars, it will be noticed, are simply strong straight bars, of equal section throughout, while the bracket which carries them is placed well forward, the bars projecting through it for a considerable distance. This arrangement of the guide-bar bracket is undoubtedly a good one to adopt, and affords far better support to the guide bars than if the bracket is placed at the extreme end of the bars, as is usually the case. The plan of placing the guide bar stay, or motion plate, well forward, has been adopted of late years in English practice for inside cylinder engines; but Herr Maffei's is the first locomotive on which we have seen it resorted to where the cylinders are outside; although with the Hall engines, so largely used on the Continent, it might be very generally adopted.

The frames of Herr Maffei's engine are made of the old double-plate form, and they are connected by very deep transverse stays. At the front end also, the frames are continued up to the leading buffer beam with the full depth they have at the cylinders, and the leading buffer beam is also made that depth, it being merely cut out to lighten it, as shown by the half-front elevation, Fig. 3, Plate CI. This arrangement considerably stiffens the front end of the engine. The buffer beam is, it will be noticed, made very short, it terminating just outside the frames, so as to allow of access to the cylinders. The total width of the engine is 10 ft., a width very considerably beyond those admissible on English lines. The axle-box guides are furnished with adjusting wedges. The wheels are 4 ft. 1 in. in diameter, and are arranged with a total wheel base of 10 ft. 5 in. only. As in some of the other six-coupled engines at the Vienna Exhibition, of which we have already had occasion to speak, the springs of the driving and trailing wheels are connected by compensating beams, the effect being as we have already pointed out, to materially diminish the control of the springs over the longitudinal oscillations or pitching motion which in engines having so great an overhang, must at times necessarily be set up. We may mention here, by-the-bye, that in the engine at the Exhibition the whole of the spring gear was got up bright, a certainly unnecessary expenditure of labour, and one that, to our eyes, did not improve the general appearance

A special feature in the locomotive under notice is that it is fitted with the Heberlein brake, the brake blocks being of cast steel, and being applied to the leading and trailing wheels, while the brake gear itself is actuated from the driving axle. The arrangement of the gear will be best understood by reference to the elevation and sectional plan (Figs. 1 and 2, Plate CI.). On examining these views, it will be seen that the transverse frame stays before and behind the driving wheels are connected near their centres by a pair of longitudinal frames, which serve to support the fulcra of a pair of bent levers, which carry between them a friction wheel or disc. These levers are loaded at their free end, and they are connected by a link to a short arm on a kind of weigh-shaft situated above them, this shaft extending out to the side of the engine, and being furnished at its outer end with a lever actuated by a rod from the footplate. By this arrangement the levers above mentioned can, when desired, be allowed to fall, when the friction disc they carry is forcibly pressed against a corresponding disc fixed at the centre of the driving axle, as shown in the plan. Motion is thus imparted to the friction disc carried by the levers, and this motion effects the winding up of chains, which draw upwards the hind end of a long horizontal lever keyed on a brake shaft extending across the engine between the leading and driving wheels. From this brake shaft the brake blocks are actuated in the ordinary way, as shown in the engravings. The Heberlein brake is just now being regarded with considerable favour on some of the Continental lines; but we cannot look upon it as an arrangement to be admired, and it certainly does not appear to possess any essential features distinguishing it from other friction wheel brakes which have been experimented upon, and, with one exception (Clark's), abandoned both here and in America.

The firebox of the engine under notice has its crown stayed direct to the roof of the firebox casing—there being no girder stays—but instead of this being done by stays screwed into both plates the connexion is effected by links with pins at each end, as shown in the transverse section, Fig. 4, Plate CI. Transverse stays are also carried acrosst he firebox casing, just above the crown of the firebox, as shown in the same view. The inside firebox is of copper, and is of the following dimensions :—

	ft.	in.		ft.	in.
Length at top	4	7⅛	Width at bottom	3	9¼
„ bottom	4	9	Height at front	4	7
Width at top	3	11¼	„ back	4	1

The boiler contains 181 tubes, these tubes—which are 2 in. in diameter, by 13 ft. 5½ in. long between tube plates—being of iron with copper rings at the firebox end. The external heating surface given by the tubes is 1,280 square feet, which with 80 square feet of firebox surface makes the total heating surface 1,360 square feet. The firegrate area is 17·9 square feet. The pressure carried on the boiler is 10 atmospheres effective, or 147 lb. per square inch. We may just mention here that the ashpan in addition to the usual dampers is provided with doors at the sides, as shown in the side elevation. These side doors to ashpans are frequently provided in Continental practice, and where—as is the case in the engine we are describing—these are thoroughly accessible they are very convenient.

The weight of the engine of which we have been speaking, is 32½ tons when empty, and 36½ tons in working order, and its tractive effort for each pound of effective pressure per square inch on the pistons is by the ordinary rule :—

$$\frac{19 \cdot 13^2 \times 26}{49} = \frac{365 \cdot 9569 \times 26}{49} = 194 \cdot 2 \text{ lb.}$$

With an effective pressure on the pistons equal to four-fifths of the boiler pressure—a pressure which could probably be maintained at slow speeds—the tractive efforts would thus amount to

$$\frac{194 \cdot 2 \times 147 \times 4}{5} = 22{,}837 \text{ lb.}$$

or a little over 10 tons, this however, being a tractive effort which could only be utilised by the available adhesive weight under exceptionally favourable circumstances.

Goods Locomotive for the Bergisch Märkische Railway, by Henschel and Son of Cassel.—Besides the passenger locomotive for the Bergisch-Märkische Railway, of which we have already spoken, there was also exhibited in the German section of the Machinery Hall a goods locomotive for the same line, this engine having been constructed by Messrs. Henschel and Son, of Cassel.

Referring to the illustrations on Plates CI. and CII., it will be seen that the engine has six coupled wheels and outside cylinders, the latter being 17½ in. in diameter by 24·7 in. stroke, while their distance apart from centre to centre is 6 ft. 7 in. The pistons are of wrought iron, with two rings sprung into place. The guide bars are very heavy, being 4 in. wide by 3 in. thick for the main part of their length; but owing to their great length these heavy proportions are necessary. The valve gear is of the ordinary shifting link kind, and is arranged inside the frames. The distance from the centre line of exhaust port to centre of driving axle is 9 ft. 11⅝ in., and the connecting rods are 7 ft. 1 in. long between centres. The connecting rods have solid ends, the brasses at the small ends being set up by a wedge and screw. The coupling rods are very thin, the ends being only about 1¼ in. thick, while the bearings are but 2 in. long. The diameters are, however, large, being 4¾ in. for the driving, and 3⅜ in. for the leading and trailing crank pins.

The wheels are 50·43 in. in diameter, and are placed with a total wheel base of 10 ft., the distance between leading and driving wheels being 5 ft. 6½ in., and that between driving and trailing wheels 4 ft. 5½ in. This, for such a long heavy engine, is a very short wheel base, necessitating an amount of overhang at each end to which English locomotive superintendents would—and we think rightly—object. As in the case of the goods locomotive from the Hannoversche Maschinenbau Actien-Gesellschaft, of which we have already spoken, the control of the pitching motion is lessened by the fact of the driving and trailing axles being connected by compensating levers. The arrangement of these compensating levers is worthy of notice, as it is one rarely employed here, but frequently resorted to on the Continent. Referring to Plate CII., it will be seen that pins extend upwards from the driving and trailing axle boxes, and bear directly on the ends of the compensating beams, which latter are placed just above the frames. Each compensating beam is formed of two plates, and the centre pin on which it rocks passes through a block which is free to move vertically in a slot cut in a bracket or guide, which is fixed to the frame, and extends up between the plates of the compensating beam. The latter is thus free to rise or fall vertically, but it is secured from movement in a fore and aft direction. Beneath the frame, and directly under the centre of each compensating beam, is placed a heavy inverted spring, the centre of which is connected by a pin to brackets which transmit its upward thrust to the frame, while the ends are connected by links with the compensating beam above, as shown. This arrangement appears to have been adopted in many instances to overcome the difficulty of getting in suitable trailing springs without diminishing the width of the firebox; but, as we have already stated, we cannot—for the reasons assigned—commend the employment of compensating beams in six-wheeled engines with such a large amount of overhanging weight.

It must be remembered that in all cases where a compensating beam is used, the pair of wheels thus connected might, as far as the power of controlling pitching motion is concerned, be replaced by a single wheel placed under the centre of the compensating beam. Thus in the engine we are describing, the effective overhang at the trailing end is as great as it would be if the engine had four wheels only, the trailing pair being situated midway between the present driving and trailing wheels, and the wheel base being thus reduced to 7 ft. 9¼ in. The two pairs of wheels connected by compensating beams have, however, of course the important advantage of distributing not only the static load, but also the additional load due to the pitching of the engine, over four points of contact with the rails, instead of two, as would be the case if the engine had four wheels only, as first supposed. As we have already stated, the low speed at which Continental goods traffic is

for the most part worked has a good deal to do with the continued employment of these short wheel-based engines; but in any case we should consider these locomotives must be very trying to the permanent way.

To return however, to Messrs. Henschel and Son's engine. The frames are, as will be seen from the plan (Plate CII.), made of two plates for part of their length and of single plates for the remainder. The double frames—which are composed of two plates $\frac{1}{2}$ in. thick placed 1 in. apart—extend from just in front of the cylinders to the front of the firebox casing, a single plate (which extends back for the length of the smokebox) connecting each frame to the leading buffer beam, while a similar plate $\frac{3}{4}$ in. thick extends along the sides of the firebox casing to the trailing buffer beam. Besides the connexions formed by the buffer beam and the bottom of the smokebox, the frames are united at the leading end by a pair of plate stays situated 1 ft. $6\frac{1}{2}$ in. in front of the leading axle, these stays serving to carry the centre of a transverse compensating beam which connects the front ends of the two leading springs. There is also another cross-stay just behind the leading axle, and a pair of cross-stays with a horizontal plate between them situated between the driving and trailing wheels, as shown by dotted lines in the side elevation. These latter stays are not shown in the sectional plan, the line of the section being taken below them. There is also the usual plate stay at the trailing end, and altogether the frames are strongly braced together. The leading buffer beam we may mention is a kind of box girder, the front and back being made of plates $\frac{5}{16}$ in. thick, and the top and bottom of channel irons with their flanges turned outwards, as shown by dotted lines in the side elevation.

The axle boxes are of wrought iron, a material of which—thanks to Mr. Haswell's having shown how readily it may be stamped—locomotive axle boxes are now largely made on the continent. Brass liners are interposed between the axle boxes and their guides or rubbing pieces, and the latter, which are also of wrought iron, are furnished with adjusting wedges. The wedges are on the front sides of the axle boxes, and it will be seen from the sectional plan that they have but a narrow bearing against the fixed guides.

The boiler (see transverse section and longitudinal section, Figs. 5 and 6, Plate CI.), has the firebox constructed on a modification of the system introduced by Herr Becker, of the Kaiser Ferdinand's Nordbahn—a system of which we shall have more to say hereafter. As will be seen from the section, the firebox crown is flat, and is connected to the sides by curves of large radius, while it is supported by stay bolts extending directly upwards to the crown of the fire-box casing. This latter crown is of the usual cylindrical form, while Herr Becker, in his own practice, makes it flat for such a width as to include all the vertical stay bolts, thus getting the latter all one length, and moreover, avoiding oblique tapped holes through the crown plate. This arrangement of Herr Becker's, with the flat crown plate to the casing, we must say we prefer to that adopted in the engine we are describing.

Like the boiler of the passenger locomotive for the same railway company, of which we have already given an account, that of the engine now under notice is very heavily stayed. Thus there are transverse stays connecting the sides of the firebox casing just above the firebox crown, while the back plate of the firebox casing and the smokebox tube plate are stiffened not only by strong gusset stays, but also by ties extending to the barrel, and placed low down, as shown in the longitudinal and transverse sections. These longitudinal stays, placed just above and below the level of the centre line of the barrel, appear to us—as we mentioned when speaking of the passenger engine—quite unnecessary, and at the trailing end they are positively objectionable, as they tend to greatly facilitate the collection of scale or deposit at the sides of the firebox. Access to the boiler for cleaning purposes is given by a large hand hole situated on each side of the top of the firebox casing, as shown in the transverse section, the openings for these hand-holes being strengthened by heavy rings, as shown, and the covers being made with a cone joint. There are also the usual mud plugs at the firebox corners, and three plugs arranged at intervals along the bottom of the barrel, as shown in the longitudinal section.

Mud plugs are rarely placed in these latter positions in this country; but they are very handy in many cases.

The barrel plates are 15 millimetres (0·59 in.), the sides and back plate of the firebox casing 16 millimetres (0·629) in.), the firebox casing crown plate 20 millimetres (0·787 in.), the smokebox tube plate 23 millimetres (0·905 in.), and the dome plates 13 millimetres (0·51 in.), thick, while all the seams of the shell are double rivetted. The firebox is of copper, the plates being 16 millimetres (0·629 in.) thick, with the exception of the tube plate, which is 29 millimetres (1·14 in.) thick at the upper part. Altogether it will be seen that the plates are very heavy; but the pressure at which the boiler is worked is high, being 10 atmospheres effective, or 147 lb. per square inch. The manner in which the firebox tube plate and the back plate of the firebox casing are flanged is a peculiarity shown by the longitudinal section of the boiler (Fig. 6, Plate CI).

The firebox is 5 ft. 0·75 in. long at bottom, by 3 ft. 1·46 in. wide at top, and 3 ft. 4·65 in. wide at bottom, while it is 5 ft. 2·78 in. high, the grate being level. The fire-grate surface is thus 15·84 square feet, and the firebox heating surface 86·5 square feet. The barrel contains 200 tubes 46 millimetres (1·81 in.) in diameter outside, 3 millimetres (0·118 in.) thick, and 14 ft. 1·69 in. long between tube plates. These tubes expose an external heating surface of 1,331 square feet, making, with the firebox surface, a total of 1,417·5 square feet.

The boiler is fitted with four safety valves of the Ramsbottom pattern, one pair being fixed on the top of the firebox casing and the other pair at the top of the dome. The dome, which is 2 ft. 4½ in. diameter by 3 ft. 1 in. high, contains the regulator, which is of the ordinary gridiron pattern, while there is also led from the dome a 4-in. collecting pipe, which passes along the top of the boiler barrel for a distance of little over 9 ft., and is slotted at intervals on its upper side. The boiler is fed by a pair of injectors arranged one on each side beneath the footplate. It will be noticed from the engravings that the boiler is fixed to the frames by the smoke-box tube plate only, this plate being stiffened by gusset stays extending back to the underside of the barrel, as shown. At the trailing end the boiler is carried by angle irons fixed at the sides of the firebox casing, as shown, so as to take a bearing on the frames.

The weight of the engine we have described is 33·18 tons empty or 37.6 tons in working order, this latter weight being distributed as follows:—On leading wheels 12·8 tons; on driving wheels 12·6 tons; and on trailing wheels 12·2 tons, the load being thus very nearly equal on all the axles. Altogether the engine is one adapted for heavy work, and on a good road, and at moderate speeds it will no doubt do this work well. At higher speeds, however, or on a road not well kept up, the short wheel base and the arrangement of the spring gear to which we have alluded above would, we should anticipate, give rise to objectionable pitching motion. The workmanship and general finish of the engine are, we may add, exceedingly good, and very crebitable to Messrs. Henschel and Son.

Tank Locomotive by the Berliner Maschinenbau Actien Gesellschaft, (formerly L. Schwartzkopff & Co.) Berlin.—One of the most carefully designed and best finished engines in the German section was the tank locomotive by the Berliner Maschinenbau Actien Gesellschaft (formerly L. Schwartzkopff and Co.) of Berlin. As will be seen from Plates CIII. and CIV., and Figs. 1 to 7, Plate CV., the engine has six wheels, the driving and leading pairs being coupled, while the trailing axle is fitted with the late Mr. W. B. Adams's radial axle boxes, there being also a special arrangement for controlling the movement of these axle boxes, of which we shall speak presently.

The cylinders, which are outside, are 16½ in. diameter by 22 in. stroke, and are well fixed to the frames by flanges all round the openings through which the steam chests are passed. The steam chest cover, it will be noticed (see longitudinal section, Plate CIV.), is circular, so that it can be faced in a lathe, and the corners of the valves are cut away, so that the valves may be introduced through the circular opening, while the valve faces are correspondingly shaped, as shown. In addition to the ordinary exhaust pipes, it will be

noticed that the cylinders are provided with passages which place the exhaust cavities in communication with a cross tube or breeches pipe, having a branch led directly forward, and fitted with an ordinary throttle valve. This valve can be worked from the footplate, and by opening it a portion of the exhaust steam can be discharged directly forward at the front of the engine, instead of passing through the exhaust nozzle. The slide valves are of Trick's pattern, a pattern of which we have already expressed a very favourable opinion. In these valves, as most of our readers are probably aware, the admission of steam takes place not only past the edge of the valve in the ordinary way, but also through channels cast in the valve itself, as shown in the sectional plan, Plate CIV. The pistons are of wrought iron, and of a light section, as shown; they are fitted with steel rings. The piston rods are enlarged in the crossheads, the glands being made in two halves held together by an outer bush of wrought iron, as shown.

The general designs of the connecting and coupling rods, &c., and also of the valve motion—which is of the Allan straight link type—are clearly shown by the engravings, and require no special notice here; we may remark, however, that the proportions are good throughout. The link motion, we may mention, is arranged so that—contrary to usual practice—the lower eccentric rod is that for fore-gear, the link being in its highest position when the engine is running forward.

The engine has inside frames only, and these although of good depth are rather light, the thickness of the frame plates being but $\frac{9}{16}$ in. The transverse connexions between the frames also appear to us rather deficient, and we especially miss the solid strong angle-iron frame which, in English practice is now almost universally introduced between the frames below the cylinders, and which adds so much to the rigidity of this part of the engine. At the trailing end, however, the engine under notice has the frames well connected by the draw plates, the tool box, and the stays belonging to the trailing spring gear, these connexions remedying, to some extent, the deficiency at the leading end, and tending to secure the squareness of the frame. The leading and trailing buffer beams are of I section—a section which is now being largely used by German locomotive builders—and these beams, being well secured to the frames, also tend to maintain the squareness of the latter. The foot-plates are finished all around their outer edges by an angle iron, fixed as shown on the sketch (Fig. 6, Plate CV.), this angle iron, which is polished on its outer side, giving a very neat finish. We believe, however, that in cases where a similar form of construction has been adopted in this country, the slight projection of the edge of the angle iron above the footplate has been found to be a source of danger, it being apt to catch the feet of the driver or fireman in getting off the footplate. Otherwise this angle iron makes, as we have said, a very neat finish, and we notice that it is being used by other German locomotive builders than the firm whose engine we are describing. The buffers of the engine under notice are, we may mention, of a very neat pattern, and are fitted with india-rubber springs, while india-rubber rings are also fitted to the safety-chain bolts. The draw springs are, however, volutes arranged as shown in the longitudinal section. The tool box, it will be noticed, is arranged beneath the footplate at the trailing end, access to it being given by doors fitted to openings in the frames. This is a very neat and convenient arrangement for the tool boxes of tank engines, and is being adopted by several firms on the Continent.

The axle boxes for the coupled wheels are of wrought iron, and the guides—which are also of wrought iron—are not fitted with any adjusting wedges. The axle boxes are forged in one of Mr. Haswell's hydraulic forging presses, which the makers of the engine under notice have at their works. The springs of the leading and driving axles are connected by compensating beams, while the trailing axle is, as we have stated, fitted with Mr. W. B. Adams's radial axle boxes, the radius of the arc described by the boxes being 5 ft. $5\frac{5}{8}$ in. The special arrangement provided for controlling the lateral movement of this axle will be best understood by reference to the transverse section at the trailing end (Fig. 1, Plate CV.). Referring to this view it will be seen that the trailing spring is placed transversely, its ends

being connected by short links to a pair of plate stays, which connect the frames at that point. The box of the spring has on its underside a spherical bearing surface, which rests in a corresponding hollow formed in a bearing piece secured between the two flitches of a double plate beam, which spans the distance between the two axle boxes. At its ends this beam is fitted with steel carrying rollers 4⅝ in. diameter, which bear on the tops of the axle boxes. The tops of these boxes are, as will be seen, fitted with steel caps, hollowed so as to form double inclines, and the effect of the load bearing on these inclines through the rollers just mentioned, of course controls the lateral movement of the axle. The trailing axle bearings, it will be noticed, have collars at the middle of their length instead of at their ends as usual. The tyres and axles are of steel.

The form and construction of the boiler, and also the arrangement of the stays, are so clearly shown by our engravings, that a detailed description is unnecessary. The firebox casing, it will be noticed, is of the Belpaire pattern, and is considerably raised above the top of the boiler barrel, the steam space thus formed being connected to the steam dome by large pipes arranged as shown. The regulator, which is placed in the dome, is of the gridiron pattern with double valves; the first movement of the lever shifting the outer valve, and giving a small opening, and the two valves subsequently moving together. The firebox is of copper, with copper stays. The general mountings of the boiler are of very neat patterns, and the joints between them and the boiler plates are made by means of "lenses," as they are called, or, in other words, brass rings convex on both sides, as shown in the sketch, Fig. 7, Plate. CV. These rings are simply interposed between the boiler plate and the mountings, and they form a perfectly tight joint. Such "lenses" are now largely used in Germany for making joints in the manner we have described, and they answer their purpose well. For pipe joints they are peculiarly applicable. It may be noticed here that in the engine we are describing the main steam pipe is at its front end brazed to a brass casting having a collar shaped to form a "lens," the inner side bearing against the smokebox tube plate, and the outer side receiving the branch pipe. The use of a loose "lens" at that point is thus avoided.

As will be seen from our engravings, the driving wheels of the engine under notice are fitted with a brake, the brake gear being arranged according to Exters' patent. This brake gear is very neat and handy, and the detail views which we give (Figs. 3, 4, and 5, Plate CV.) will explain its peculiarity clearly. Referring to these engravings, it will be seen that the brake shaft carries a lever provided with a nut for the brake screw as usual; but this brake screw is not employed directly for applying the brake, but merely for adjustment and taking up wear, and it is thus furnished at its upper end with a small hand wheel only. The brake screw rod has also at its upper end a collar which rests upon a bush through which the rod passes, this bush having a pair of trunnions which enter into short crank arms as shown. These crank arms are formed on a couple of short spindles which turn in bearings at the top of the brake pillar, and which have hand levers fixed at their outer ends. The two hand levers are connected at one end by a cross handle, and at the other by a counterweight as shown. It will be understood from this description that the two cranks form the short arm of a lever, of which the long arm is represented by the pair of hand levers just mentioned, and it will also be seen that when near the top of their throw the action of the cranks on the brake screw rod is similar to that of a toggle joint, and a very powerful pull can thus be exerted on the brake screw rod if its length be properly adjusted. The normal position of the arrangement is that shown by dotted lines in the longitudinal section (Plate CIV.), the hand lever being then in its lowest position and the counterweight raised. To put on the brake, the hand lever is pulled up into the position shown by the detail views, Figs. 3, 4, and 5, Plate CV., the swing of the counterweight assisting in the application of the brake, and keeping it applied when in the position shown. The whole arrangement is a very neat and effective one, and enables the brake to be applied very promptly.

The boiler is fed by a pair of Schau's injectors fixed beneath the footplate, the feed water being carried in a pair of wing tanks, while the sand boxes

are arranged on the top of these tanks as shown in the transverse section (Fig. 2, Plate CV). These tanks have a total capacity of 814 gallons. The fuel is carried at the hind end of the footplate in two bunkers arranged as shown in the plan on Plate CIII., these two bunkers holding together about 10½ cwt. of fuel. The footplate is protected by a neat cab, as shown, and the general finish of the engine is, as we have already stated, excellent. In the engravings the principal dimensions are all fully given in metrical measures; but for convenience of reference we subjoin a Table in which these dimensions are given, reduced to English standards, the Table also containing the heating surfaces and other particulars not given by the illustrations.

	ft.	in.
Cylinders:		
Diameter	1	4½
Stroke	1	10
Distance apart from centre to centre	6	4·7
Distance from centre line of exhaust port to centre of driving axle	9	5½
Distance from valve face to centre line of cylinder	1	10·2
Length of steam ports	1	1⅞
Width of „ „	0	1·1
„ exhaust ports	0	1·57
„ bars	0	0 15/16
Working gear:		
Length of connecting rods between centres	5	8
Length of connecting rod bearings; large end	0	3·86
Diameter of connecting rod bearings; large end	0	3·58
Length of connecting rod bearings; small end	0	2·6
Diameter of connecting rod bearings; small end	0	2·6
Length of coupling rod bearings	0	2·6
Diameter of coupling rod bearings on driving crank pins	0	4·13
Diameter of coupling rod bearings; leading crank pins	0	3·6
Section of connecting rod at large end, 3·07 in. by 1·65 in.		
Section of connecting rod at small end, 2·6 in by 1·65 in.		
Section of coupling rods at centre, 3·07 in. by 1·42 in.		
Section of coupling rods at ends, 2·6 in. by 1·42 in.		
Diameter of piston rods	0	2·44
Length of eccentric rods	3	7½
Length of expansion links between end centres	1	3 15/16
Frames:		
Distance between frames	4	0 5/16
Thickness of frames	0	0·9
Total length of frames over buffer beams	24	1
Total width of engine over footplates	9	1⅛
Width of cab	8	4
Length „	6	4½
Height „ at centre	6	4½
„ of footplate above rail	4	0¼
Wheels, axles, and springs:		
Diameter of coupled wheels	4	6
„ „ trailing „	3	0
Distance between centres of coupled wheels	5	8
Distance between centres of driving and trailing wheels	7	6 9/16
Total wheel base	13	2 5/16
Radius of arc described by trailing axle	5	5½
Distance from centre of driving axle to front of firebox casing	1	8·6

	ft.	in.
Wheels, axles, &c.—cont.		
Bearings of coupled axles; length	0	6·9
Bearings of coupled axles; diameter	0	6·7
Bearings of coupled axles; centres	3	7
Bearings of trailing axle; diameter	0	6 3/16
Bearings of trailing axle; length	1	0⅝
Bearings of trailing axle; centres	3	6·2
Springs for coupled axles; length between centres	3	1
Springs for coupled axles; number of plates 10		
Springs for coupled axles; width of plates	0	3·58
Springs for coupled axles; thickness of plates	0	0½
Spring for trailing axle; length between centres	3	4
Spring for trailing axle; number of plates 27		
Spring for trailing axle; width of plates	0	3·62
Spring for trailing axle; thickness of plates	0	0·35
Boiler:		
Diameter of barrel inside largest plate	3	9½
Length of barrel	10	0½
Length of firebox casing, outside	4	10 11/16
Width of firebox, casing outside at bottom	3	8½
Width of firebox casing, outside at widest part	4	0 7/16
Height of firebox casing, outside at front	6	10⅜
Height of firebox casing, outside at back	6	5⅛
Height of crown of firebox casing above centre line of boiler	2	10
Length of inside firebox at top, inside	4	0⅜
Length of inside firebox at bottom, inside	4	4½
Width of inside firebox at bottom, inside	3	3⅜
Width of inside firebox at top, inside	3	1⅝
Height of inside firebox at front	4	9¼
Height of inside firebox at back	4	3⅝
Thickness of barrel plates	0	0 7/16
„ „ smoke-box tube plate	0	0 13/16
Thickness of front and back plates of firebox casing	0	0 9/16
Thickness of side and crown plates of firebox casing	0	0½

Boiler—cont.	ft.	in.
Thickness of side and crown plates of inside firebox (copper)	0	$\frac{5}{8}$
Thickness of back plate of inside firebox (copper)	0	$\frac{1}{2}$
Thickness of tube plate upper part	0	1
Thickness of tube plate lower part	0	$\frac{1}{2}$
Number of tubes - 156		
Length of tubes between tube plates	10	$2\frac{5}{16}$
Diameter of tubes (outside)	0	1·93
[The diameter is increased to 2 in. in the front tube plate and reduced to 1·8 in. in the firebox tube plate.]		
Distance, vertically, between centres of tubes	0	$2\frac{1}{2}$
Distance, horizontally, between centres of vertical rows of tubes	0	2·2
Length of smokebox	2	$2\frac{3}{4}$
Diameter of chimney	1	$3\frac{7}{16}$
Diameter of blast nozzle	0	4·09

Boiler—cont.	ft.	in.
Length of chimney above top of smokebox	5	$1\frac{3}{4}$
Height of centre line of boiler above rails	5	11

Heating surface:	square feet.
Firebox	69·8
Tubes (external)	817·6
Total	887·4
Firegrate area	13·24 sq. ft.
Pressure of steam	127 lb. per sq. in.
Contents of tanks	814 gallons
„ coal bunkers	10½ cwt. tons.
Weight of engine empty	25·52
Weight of engine in working order:	
On leading wheels	12·76
„ driving „	12·76
„ trailing „	8·85
Total	34·37
Weight on coupled wheels	25·52

Tank Locomotive for the 2ft. 7in. gauge, by the Maschinenbau Gesellschaft, Carlsruhe.—One of the neatest little engines in the German section was the four-wheeled tank locomotive for 2 ft. 7 in. gauge, constructed by the Maschinenbau Gesellschaft, Carlsruhe. Of this engine, which had been built for the Royal Hungarian coal mines at Petrozseny, we give views showing the general construction clearly (Fig. 8, Plate CV. and Plate CVI.). From the illustrations it will be seen that the engine has outside cylinders and outside valve gear, the latter being of the shifting link type. It will be noticed, on examining the side elevation, that the valve spindle is kept horizontal, and that the motion is transferred from the expansion link to the valve rod through the intervention of a vibrating lever, this lever oscillating on a fulcrum carried by the guide bar bracket. The wheels are cast-iron discs, with steel tyres, and the crank pins have spherical bearings for the coupling rods. The latter have open fork ends for the driving crank pins, so that they can, if necessary, be taken off without removing the connecting rod. The engine is carried on a pair of leading springs, and a transverse trailing spring, so that it is supported on three points. The axle boxes and axle-box guides are of cast iron.

At the leading end the frames are well connected by a cast-iron box cross stay introduced below the smokebox, as shown in the plan and half-transverse section, this cross stay being held by some of the bolts which secure the cylinders. A cast-iron tube, passing down through the box, and provided with a valve, gives the means of discharging the ashes from the smokebox. The buffer beams are of channel section, and a minor point, worthy of notice, is the manner in which, to avoid cutting the upper flange of the trailing buffer beam, the nut on the brake screw is coupled by a curved link to the lever on the brake shaft. Cast-iron slides to receive the frames are bolted on the sides of the firebox, a rubbing piece of brass being interposed between the top of each frame and its cast-iron guide. The water is carried in a pair of wing tanks, and the boiler is fed by two injectors placed below the footplate level. The general design of the details is very good, and the finish excellent. The illustrations we give are fully dimensioned according to the metric scale, but, for convenience, we as before subjoin a list of the principal dimensions in English measures:—

Cylinders:	ft.	in.
Diameter	0	$8\frac{3}{4}$
Stroke	1	1
Distance apart from centre to centre	3	$10\frac{3}{4}$
Distance from centre of exhaust ports to centre of driving axle	7	$6\frac{1}{2}$
Wheels and axles:		
Diameter	3	$2\frac{1}{4}$
Wheel base	4	$8\frac{1}{4}$

Wheels and axles—cont.	ft.	in.
Diameter of axle bearings	0	$4\frac{1}{4}$
Length of axle bearings	0	5
Centres of axle bearings	1	11
Centre of driving axle to front of firebox casing	0	$6\frac{7}{8}$
Frames:		
Distance between frames	2	$2\frac{7}{16}$
Thickness of frames	0	$0\frac{5}{8}$
Length outside buffer beams	16	$3\frac{1}{4}$
„ of engine over buffers	18	$10\frac{1}{2}$

Frames—cont.	ft.	in.
Width of engine over tanks	6	$3\frac{9}{16}$
Centres of buffers	1	$11\frac{1}{8}$
Height of centre of buffers from rail	0	$11\frac{13}{16}$
Boiler:		
Diameter of barrel inside largest plate	2	$7\frac{1}{2}$
Length of firebox casing	3	$5\frac{3}{8}$
Width " " at bottom	2	$1\frac{1}{4}$
Height of centre line of boiler above rails	3	$8\frac{7}{8}$
Diameter of chimney at narrowest point	0	$8\frac{27}{32}$
Diameter of chimney at top	1	$1\frac{3}{4}$
Thickness of firebox plates (copper)	0	$0\frac{5}{32}$
Thickness of firebox tube plate (copper)	0	$0\frac{5}{16}$

Boiler—cont.	ft.	in.
Thickness of boiler shell plates (iron)	0	$0\frac{11}{32}$
Number of tubes 77		
Length of tubes between tube plates	7	$6\frac{1}{2}$
Diameter of tubes outside	0	$1\frac{21}{32}$

Heating surface:	sq. ft.
Tubes (outside)	251·5
Firebox	23·5
Total	275·0

Firegrate area	5·16 sq. ft.
Contents of tanks	184 gallons
Contents of coal boxes	$5\frac{1}{2}$ cwt.
Weight of engine empty, 8 tons	19 cwt
Weight of engine in working order, 11 tons $2\frac{1}{2}$ cwt.	

Tank Locomotive for the Upper Silesian Railway, by F. Wohlert, Berlin.—The next engine we have to notice is one exhibited by the Upper Silesian Railway Company, this being a six-coupled tank locomotive constructed for them by Mr. F. Wohlert, of Berlin. From the illustrations (Plate CVII., and Fig. 4, Plate CVIII.), it will be seen that the engine has outside cylinders and inside frames, while the valve motion, which is of the straight link type, is also inside. The valve chests, it will be noticed, have circular covers. The motion generally is of good proportions, and the connecting rod ends are fitted with an arrangement for securing the cotters which, although adopted by several continental makers, is, as far as we are aware, not used in this country. The detail view, Fig. 4, Plate CVIII., shows this arrangement. From the sketch it will be seen that a loose piece *a* is fitted to the opening in the rod end at one side of the cotter, and that a set bolt *b* traverses this piece and the cotter, and is tapped into the nut *c*. When the bolt *b* is slack the cotter is free to be adjusted, but when the bolt is screwed up the cotter, is clipped tightly between the piece *a* and the nut *c*, and as the piece *a* is of course incapable of moving endways, the cotter is securely held.

The springs are arranged beneath the axle boxes, and those of the leading and middle wheels are connected by compensating beams, arranged as shown. The framing is well stiffened by cross stays, and at the trailing end additional rigidity is gained by building in a tool box below the footplate, access to this box being gained through doors fitted to openings in the side frames. The buffer beams are of I section, a section which, as we have remarked, is adopted by several other German makers. The drawbar at the trailing end is arranged on a system which is now being largely adopted on the continent, and which deserves to be extensively used here. Referring to the plan, it will be seen that the drawbar, instead of being hinged directly to the drawplates or buffer beam, is furnished at its inner ends with a cross-piece, from the ends of which links extend back to the buffer plate. The effect of this arrangement (known as the Stradal draw gear) is, that when the hind end of the draw-hook is drawn to one side by an oblique strain, the inner end is also carried to the same side but in a lesser degree, and the effect is the same as if the drawbar was much longer, and was coupled to the engine at a point well forward.

The boiler has a roomy firebox casing of the flat-topped Belpaire pattern, and the bottom of the firebox is sloped away to allow of the trailing axle being placed beneath it. The firegrate has an opening at the centre for the admission of air, this opening being surrounded by a firebrick wall, and surmounted by a wrought-iron cap, as shown in the longitudinal section. The boiler shell is of steel, and the back plate of the firebox casing and the smokebox tube-plate are stiffened by gusset stays, as shown. The boiler is provided with a large dome, and is fitted with two sets of Ramsbottom's safety valves. The boiler is fed by two injectors arranged below the footplate, and from one of the delivery clack boxes a small pipe is led into the smokebox, so that water can be delivered into it when desired for the purpose of extinguishing any fire there. This arrangement is applied on several of the German engines exhibited, and it appears likely to prove very useful where the fuel burnt is of such a character that many ignited pieces find their way into the smokebox. This water jet in the smokebox, if properly applied,

is stated to form a good spark-arrester. The water is carried in wing tanks, these tanks being fitted with glass windows for showing the water level. The fuel is carried in boxes at the back of the footplate, and the latter is protected by a comfortable cab fitted with front and side windows. Altogether the engine is of a good and substantial design, and the workmanship was very good also, but the painting was scarcely in such good taste as could be desired, and did not show off the engine fairly. The following are the principal dimensions of the locomotive, of which we have just been speaking :

	ft.	in.
Cylinders:		
Diameter	1	5½
Stroke	2	0½
Distance apart from centre to centre	6	7½
Length of ports	1	1⅝
Width of steam ports	0	1¾
„ exhaust ports	0	3
„ of bars	0	1
Distance from centre line of exhaust port to centre of driving axle	10	0½
Working gear:		
Length of connecting rods between centres	6	3
Diameter of bearings of connecting rods, large ends	0	3⅝
Length of bearings of connecting rods, large ends	0	4⅛
Diameter of coupling rod bearing on driving crank pin	0	4
Length of coupling rod bearing on driving crank pin	0	4
Diameter of coupling rod bearings on leading and trailing crank pins	0	3⅝
Length of coupling rod bearings on leading and trailing crank pins	0	3
Length of eccentric rods	4	1¼
Transverse distance between centres of valve spindles	2	9
Wheels and axles:		
Diameter of wheels	4	7½
Distance between leading and driving wheels	6	1
Distance between driving and trailing wheels	6	3
Total wheel base	12	4½
Diameter of axles in wheel seats	0	7
Diameter of axles in centres	0	6
„ „ at bearings	0	6
Length of bearings	0	6
Centres of bearings	3	10
Width of tyres (steel)	0	5⅞
Distance from centre of driving axle to front of firebox casing	1	10⅛
Frames:		
Thickness of frames	0	1
Depth „ „	2	5
Distance apart of frames	4	0
Total length inside buffer beams	26	6
Depth of buffer beams	1	8¾

	ft.	in.
Frames—cont.		
Maximum width of engine over footplate	9	2½
Boiler:		
Diameter of barrel inside largest plates	4	3
Length of barrel	10	3
Length of firebox casing	5	4
Width of firebox casing	3	11½
Height of firebox casing above centre line of boiler	2	10½
Depth of firebox casing below centre line of boiler at leading end	4	3½
Depth of firebox casing below centre line of boiler at trailing end	3	0
Length of inside firebox at top	4	6
„ „ „ bottom	4	7½
Width of inside firebox at bottom	3	3
Diameter of dome	2	2½
Height of dome from top of barrel	3	5½
Thickness of barrel plates (steel)	0	0
Thickness of firebox casing plates (steel)	0	0
Thickness of dome plates (steel)	0	0
Thickness of smokebox tube plate (iron)	0	1
Thickness of smokebox plates (iron)	0	0
Thickness of firebox plates (copper)	0	0
Thickness of firebox tube plate (copper)	0	1
Diameter of chimney	1	4½
Height „ top of, above rails	14	1½
Number of tubes	215	
Diameter of tubes outside	0	1
Length „ „	10	7½
Heating surface:		sq. ft.
Tubes (outside)		1,080·6
Firebox		120·
Total		1,200·6

Firegrate area - 15 sq. feet.
Pressure of steam, 124 lb. per sq. inch.
Contents of water tanks, 880 gallons.
„ coal bunkers, 30 cwt.
Weight of engine in full working order, 40 tons.

Four-wheeled Tank Locomotive by Krauss & Co., Munich.—We have now to notice a group of engines possessing many distinguishing characteristics, these being the three tank locomotives shown by Messrs. Krauss and Co., of Munich. Since the establishment of their works in 1866 Messrs. Krauss have made tank engines their speciality, and they have established a system of rating and selling these engines according to their horse power, just as portable engines are constructed and sold in this country. The three engines exhibited by them at Vienna were rated at 370 horse power, 150 horse power, and 30 horse power respectively, and taken together they formed an interesting series

of examples of the special features which distinguish Messrs. Krauss and Co.'s designs.

One leading point which Messrs. Krauss and Co. have kept in view in designing their engines is to reduce to the smallest possible amount all dead weight which is not directly conducive to an increase of power. Thus their tank engines have in all cases all the wheels coupled—the smaller engines have two pairs and the larger three pairs of wheels—while the frames are so constructed that the main frame plates form the sides of water tanks. The boiler also is made entirely independent of the frame, the latter acting merely as a base for the former, while the boiler is of course supported so that it can expand and contract freely. The peculiarities of Messrs. Krauss's engines can, however, probably be best explained by describing a particular example, and we may select for this purpose the 150 horse power engine shown by them at Vienna, and of which we give outline longitudinal and transverse sections on Plate CVIII., Figs. 2 and 3.

This four-wheeled shunting engine is of a type now being largely used on the Bavarian State Railways and other lines, and it is, as we have said, rated by Messrs. Krauss at 150 horse power. It has outside cylinders 11⅝ in. in diameter by 1 ft. 9½ in. stroke, these being placed horizontally as shown, with the valve chests above them. The valve face is placed at an inclination, as will be seen by referring to the longitudinal section, and the valve motion, which is outside, is of the Allan straight link-type, the expansion link being a solid bar which is embraced by the sliding block. The reversing gear is exceedingly simple. The lever on the weigh bar is made very long, and it in fact forms the reversing lever. From it a rod extends back to the foot-plate, and the reversing is effected by simply pulling or pushing this rod, a screw clip giving the means of fixing the reversing rod in any desired position. The centre line of the valve motion, we may mention, is not in a direct line with the valve spindle, but the latter is well guided, and is thus protected from the effect of any side strain.

The wheels are 3 ft. 2$\frac{3}{16}$ in. in diameter, and are placed 8 ft. 0½ in. apart from centre to centre. The springs are arranged so that the engine is carried on three points, there being a pair of leading springs and a transverse trailing spring, as shown. This arrangement is adopted by Messrs. Krauss for all their four-wheeled engines. The frame plates are connected by cross plates, so as to form the sides of two tanks, one situated between the two axles and the other in front of the leading axle, as shown in the longitudinal section. These two tanks together hold 770 gallons of water, and from their position the centre of gravity of the engine when in working order is kept low. The fuel is carried in bunkers at the sides of the firebox, these bunkers having together a capacity of 13 cubic feet. Besides being connected by the tops, bottoms, and ends of the tanks, the frames are also connected by the trailing buffer beam, and by stays behind and in front of the firebox, this latter stay and the hind end of the hind tank (which end is strengthened for the purpose), serving to receive the upward thrust of the trailing spring.

The boiler is as we have said, entirely independent of the frame. At the trailing end the firebox is carried by slides bearing on the frame, while at the leading end the boiler is supported and fixed by the front plate of the smokebox being bolted to an angle iron, which is rivetted to the top plate of the front tank, as shown in the longitudinal section. A tube passing from the smokebox down through this tank serves for the discharge of ashes. The firebox casing is made flush with the barrel, and its crown and that of the firebox are connected by vertical iron stay bolts, as shown, the firebox crown being connected to the sides by curves of large radii, so that there are but four rows of these stay bolts required.

Messrs. Krauss are one of the few firms of continental locomotive engineers who do not use domes, and their engines are all fitted merely with a small external casing containing the regulator, this casing being connected with a steam collecting pipe, slotted along its upper side, which extends along the top of the barrel, as shown, and terminates just clear of the manhole. This latter is formed on the barrel, as shown, and its cover carries a pair of Ramsbottom's safety valves. The boiler contains 127 tubes 1·61 in. inside

and 1·73 in. outside diameter, and 10 ft. $11\frac{7}{8}$ in. long between tube plates. The tubes have thus an external surface of 631 square feet, while the firebox surface is 48·4 square feet, thus making the total heating surface 679·4 square feet. The firegrate area is 9·6 square feet, and the pressure at which the boiler is worked is 10 atmospheres effective, or 147 lb. per square inch. The boiler is fed by a pair of injectors with fixed nozzles arranged below the footplate.

The engine is provided with a brake applied to the trailing wheels, this brake being arranged on Exter's system, a system which we have already described in detail. The arrangement is, as we have already said, a very good and handy one. The weight of the engine we have been describing is 19 tons empty, or 24 tons in working order, these weights being equally distributed between the two pairs of wheels. The effective draught of the engine is given by Messrs. Krauss as 2,100 kilogrammes, or 4,620 lb. It will be seen, however, from the dimensions above given, that this tractive force corresponds only to that due to an effective pressure of about 64 lb. per square inch on the pistons, and at slow speeds, therefore the engine could of course exert a much greater pull.

Six-coupled Tank Engine, by Krauss & Co., Munich.—The largest of the three locomotives exhibited by Messrs. Krauss was a six-coupled tank engine of the type built for the Kronprinz Rudolfs Railway, the Warsaw-Vienna, and the Dniester Railways, and the leading features of its construction are similar to those which we pointed out when speaking of the engine last described. Like it, the six-coupled engine has outside cylinders, outside valve motion of the straight link type, a tank frame, and a flush-topped boiler without a dome. The cylinders are $16\frac{1}{16}$ in. in diameter with $24\frac{7}{8}$ in. stroke, while the wheels are 3ft. $10\frac{5}{8}$ in. in diameter, and arranged with a wheel base of 10 ft. $4\frac{3}{8}$ in., all the axles being in front of the firebox. The driving and trailing axle boxes are connected by compensating beams, a single spring on each side, connected to the compensating beam, serving for the two axles. The wheels have the balance weights forged solid with them, and the axle boxes are all fitted with adjusting wedges.

As will be seen from the illustration (Fig. 1, Plate CVIII.), all the details of the motion and the fittings generally are very neat. The connecting and coupling rods are of I section; and the piston rods are prolonged through the front cylinder covers. The cylinders are lubricated by an apparatus designed and patented by Herr Kernaul, the manager of Messrs. Krauss's works. The expansion link is of the solid bar type, to which we have already referred, and the engine is fitted with screw reversing gear and the Heberlein brake.

The engine now under notice has 169 tubes, 1·89 in. in diameter outside and 1·73 in. inside, and 13 ft. $1\frac{3}{8}$ in. long between tube plates. The external tube surface is thus 1,097 square feet, making with 83·9 square feet of firebox surface, a total heating surface of 1,180·9 square feet. The grate surface is 16·46 square feet. The engine carries 1,100 gallons of water, and has coal bunkers with a capacity of $21\frac{1}{2}$ cubic feet, while it weighs $26\frac{1}{2}$ tons empty and 38 tons in working order, this latter weight being divided as follows:—On leading wheels 14 tons, on driving wheels 12 tons, and on trailing wheels 12 tons. The pressure of steam carried is 10 atmospheres effective, or 147 lb. per square inch, while the engine is rated by Messrs. Krauss and Co. at 370 horse power, and its effective tractive power in ordinary work is given as 3,700 kilogrammes or 8,140 lb.

Four-wheeled Tank Locomotive for the 29·52 *in. gauge by Krauss and Co., Munich.*—The third engine shown by Messrs. Krauss and Co. was a small locomotive rated at 30 horse-power, and intended for working a line of 0·75 metre (29·52 in.) gauge belonging to the Kronsladter Coal and Iron Company. It is a four-wheeled engine with outside cylinders, 6·22 in. in diameter, and 11·81 in. stroke. The valve motion, which is of the Stephenson link type, is also outside, and the reversing gear is similarly arranged to that of the other four-wheeled engine first noticed. The frames form water tanks, as in Messrs. Krauss's other locomotives, and the present engine is fitted with central buffers, the drawbars being arranged below them. The wheels are 1 ft. $10\frac{7}{16}$ in. in diameter, and arranged with a wheel base of 3ft. $7\frac{5}{16}$ in. At each end the engine is fitted with strong angle irons fixed below the frames, these angle irons being so arranged and bent that they not only serve to clear the line

from stones, &c., but will also prevent the engine from falling over in the event of its running off the rails. The boiler of the engine under notice contains 80 tubes, 1·38 in. inside, and 1½ in. outside diameter, and 6 ft. 2¼ in. long between tube alates. These tubes give an external surface of 194 square feet, making, with 13·9 square feet of firebox surface, a total heating surface of 207·9 square feet. The firegrate area is 3·23 square feet. The engine carries 114 gallons of water, and its fuel boxes have a capacity of 2·15 cubic feet; its weight is 5·2 tons empty, and 6·3 tons in working order, 3·25 tons of this latter weight resting on the leading wheels, and 3·05 tons on the driving wheels. The boiler is worked at a pressure of 12 atmospheres effective, or 176½ lb. per square inch, while its ordinary effective tractive power is given by Messrs. Krauss as 580 kilogrammes, or 1,276 lb.

The workmanship of the whole of Messrs. Krauss and Co.'s engines was excellent, and in all of them the details of the designs were very well and neatly worked out. There can be no doubt, too, that the system on which they are built, namely, that of making the frames parts of water tanks– is one possessing many advantages, the only objection to it being the tendency to leakage which the strains thrown upon the frames induce. Messrs. Krauss, however, claim to have no difficulty in this respect, and it is certain that their engines have a high reputation on the Continent, a reputation which they would scarcely have attained had the leakage been frequent or troublesome. The system of water-tank frames is, of course, also applicable to tender engines, the tanks on the engine then forming an auxiliary to the main water supply, and serving also, in some cases to effect a better distribution of weight. It is, however, as applied to tank engines proper that the system possesses the greatest value, and it no doubt enables such engines to be constructed with a reduced weight for any given power and fuel and water-carrying capacity.

Four-wheeled tank locomotive by the Maschinenfabrik und Eisengiesserei Darmstadt.—In strong contrast in point of finish to the engines which we have just described were two small tank locomotives constructed by the Maschinenfabrik und Eisengiesserei Darmstadt, which were also shown in the German section of the Machinery Hall. They were both four-wheeled tank engines, with outside cylinders, one engine being for the normal 4 ft. 8½ in. and the other for a 3 ft. 1⅜ in. gauge. We shall describe the larger of the two engines first.

As will be seen from the engravings, Figs. 1 and 2, Plate CX., the engine under notice is carried on four coupled wheels, while the frames are also arranged so as to form the sides of the water tank, which thus extends the whole width between the frames under the boiler on Krauss's system. The fuel is carried in a bunker at the back of the footplate, the back of this bunker being curved so as to "fall under," a form which mars the appearance of the engine, but which enables the total length over buffers to be slightly reduced.

All the space between the frames being occupied by the tanks, the valve motion—which is of the Allan straight link type—is of course arranged outside. The wheels are steel disc wheels, made by the Bochum Company; the trailing wheels are fitted with a brake. The workmanship of the engine exhibited was somewhat rough, there being no attempt at a high finish; but we understand that the type is one which is much liked, and is found to do good work. The engine is rated by its makers as being capable of hauling a load of 400 tons on a level at a rate of 15 kilometres, or 9·3 miles per hour, or of taking a load of 120 tons up 1 in 100. The principal dimensions are subjoined:

	ft.	in.
Diameter of cylinder	0	11·8
Stroke	1	7·7
Diameter of wheels	3	3⅜
Wheel base	6	6¼
Height of centre of boiler above rail	5	5⅝
Length of firebox inside	2	5⅛
Width „ „	2	7½
Height „ „	3	1¼
Number of tubes	83	
Diameter of tubes outside	0	1·97
Length „ between tube plates	8	6

Heating surface:	sq. ft.
Firebox	34·9
Tubes (outside)	364·
Total	398·9

Firegrate area, 6·4 square feet.
Pressure of steam, 117·6 lb. per sq. in.
Contents of coal bunker, 5 cwt.
„ tank, 440 gallons.
Weight of engine empty, 14 tons. } equally divided between axles.
Weight of engine in working order, 18½ tons. }

Four-wheeled tank locomotive for the 3 ft. 1⅜ in. gauge by the Maschinenfabrik und Eisengiesserei Darmstadt.—The second and smaller engine of these makers was as we have said constructed for a 3 ft. 1⅜ in. gauge and is intended for use about iron works or mines. As will be seen from our engravings, Figs. 3 and 4, Plate CIX., the engine has four coupled wheels, outside cylinders, and outside valve gear, the latter being of the ordinary lifting link type. The frames form the sides of the tank, as in Krauss's engines, while the coal bunkers are at the sides of the firebox. A brake arranged as shown, is applied to both sides of the trailing wheels, and the footplate is protected by a cab. The finish of the engine exhibited was very far from being good, while the design of many of the details betrayed a great disregard of appearances; but we believe that these engines do their duty well, and as they are intended for places where they have to do rough work, appearance is a matter of secondary importance. The principal dimensions of the engine we illustrate are as follows:

	ft.	in.
Diameter of cylinders	0	8·86
Stroke	1	1·78
Diameter of wheels	2	1·83
Wheel base	4	7½
Length of engine over all	15	9
Width " "	5.	6½
Height " "	9	7¼
Length of firebox	2	3·6
Width of firebox at widest part	1	10
Height of firebox	2	3·6
Length of firegrate	2	2·6
Width "	1	5·6
Number of tubes	64	
Length "	5	11
Diameter "	0	1·61

Heating surfaces:	sq. ft.
Tubes	159·6
Firebox	22·6
Total	182·2

Firegrate area, 3¼ sq. ft.
Pressure of steam, 120 lb. per sq. in.
Contents of tanks, 198 gallons.
" coal bunkers, 3 cwt.
Weight of engine empty, 7·2 tons.
" in working order (equally distributed on the two axles), 9 tons.

The engine is intended to take a gross load of 160 tons on a level at a speed of 9 kilometres, or 5·6 miles per hour (the resistance being calculated at $\frac{1}{200}$th of the weight hauled), or a load of 58½ tons up gradients of 1 in 100.

Four-wheeled tank locomotive by the Hartzer Iron Works.—The only locomotive in the German section now remaining to be noticed is that exhibited by the Hartzer Iron Works, Rubeland and Zorge. This was a small tank locomotive of a class constructed at their engine works at Zorge, Hartz, for use on lines connected with iron works and mines, and was suited for a line of the normal gauge. It will be seen from our illustrations, Figs. 1 and 2, Plate CIX., that the engine is carried on four coupled disc wheels 1 ft. 11⅝ in. in diameter, the wheel base being 5 ft. 1⅞ in.

The cylinders, which are 7⅞ in. in diameter by 9 3/16 in. stroke, are outside, and are fixed at a rather steep angle so as to allow of their being placed above the wheels. The connecting and coupling rods are of round section, and have solid ends of neat design. The driving axle carries but two eccentrics, one for each side of the engine, and a constant motion is imparted from each of these eccentrics to the corresponding valve through the intervention of a rocking lever, as shown. The reversing is effected by a lever which shifts a distribution valve which causes the currents of live and exhaust steam to change places, the exhaust port becoming the inlet steam port and *vice versâ*.

The boiler is vertical and is 3 ft. 7⅜ in. diameter inside the largest plate. The thickness of the plates is $\frac{5}{16}$ in. and the pressure of steam 120 lb. per square inch. The boiler contains 104 tubes, 1·77 in. in diameter inside and 2 in. diameter outside, the immersed portion of these tubes together with the firebox exposing a total heating surface of 117 square feet. The firegrate area is a little under 3 square feet. The boiler is fed by two of Schau's injectors fixed to the buffer beam at the driver's end of the engine, and the feed water is carried in a tank at the other end. The coal bunker is situated behind the driver, and the stand for the latter is protected by a cab. Other points of arrangement will be readily understood from an inspection of the engravings. The axles, bearing springs, piston rods, and crank pins are made of cast steel, and the boiler of best Lowmoor plates.

The engine we have described weighs 7½ tons empty, and is capable of drawing a load of 150 tons on a level, or 42 tons up a gradient of 1 in 100. Two other sizes of the same class of engine are also constructed at the Harzer Iron Works, the principal dimensions of these being as follows :

Diameter of cylinders - -	6·1 in.	9·8 in.
Stroke „ „ - -	9·8 „	9·8 „
Heating surface - - -	86 sq. ft.	183·6 sq. ft.
Weight hauled on level -	100 tons	200 tons.
„ „ up 1 in 100 -	30 „	60 „

The engine we have described is of a size between those just mentioned, and it will no doubt serve well for the class of work for which it is intended.

Austria and Hungary.

Before describing the locomotives exhibited at Vienna in the Austrian and Hungarian sections, it appears to us advisable to say a few words concerning the conditions under which Austrian engines are employed, and the duties they have to perform.

Austria is (with the exception of Hungary) a country of a decidedly mountainous character, and most of its railways traverse to a greater or less extent hilly districts, while at the Alpine passes in the Tyrol and Styria, at the Bremmer and the Semmering, the lines approach the limits of perpetual snow. In the Crown lands of Upper Austria, Styria, Tyrol, Carinthia, and Carniola, the railways—situated as they are within the boundaries of the Austrian Alps—are thoroughly mountain lines, while the railways of Bohemia, Moravia, and Lower Austria, pass through the districts of the Riesen-Gebirge, the Alps, and the low extensions of the Carpathians in Gallicia, the latter range being traversed by a tunnel at Tablunkau, by the Warsaw and Oderberg Railway.

The lines are thus all laid out with heavy gradients and sharp curves, and there is no Austrian railway of importance which has not some long gradients of 1 in 100 and more. This gradient has been accepted as a maximum only for the main lines in Moravia, Lower Austria, and Bohemia, whilst steeper gradients, such as 1 in 70, and 1 in 50, have been adopted in the other Crown lands. On the Alpine lines, moreover, gradients of 1 in 40 over distances of from 12 to 16 miles are frequently to be met with. The radii of the curves are, of course, proportionate to the gradients. On the large main lines, such as the Southern of Tyrol and the Rudolfsbahn, the radii of curves have been reduced to 200 metres (656 ft.), and, in case of need, even to 180 metres (590½ ft.). The lines in the hilly districts of Bohemia, Moravia, &c., are constructed with more easy curves. We thus find that in 1870 there were on the Austrian railways:

16½ miles with gradients steeper than - -	1 in 40
265 miles with gradients less than 1 in 40, but steeper than - - - - -	1 in 100
492 miles with gradients less than 1 in 100, but steeper than - - - - -	1 in 200
393 miles with gradients less than 1 in 200, but steeper than - - - - -	1 in 300

and

	metres.	ft.
33 miles with curves of radii under - -	200 =	656
189 miles with curves of radii between 200 metres and - - - - -	400 =	1,312
156 miles with curves of radii between 400 metres and - - - - -	600 =	1,968
122½ miles with curves of radii between 600 metres and - - - - -	800 =	2,624

while, of a total length of 3,218 miles of railway, only 710 miles were horizontal, and but 1,798 miles straight lines. Since 1870 the proportion of steep gradients and curves to horizontal and straight lines has been considerably altered by the construction of numerous mountain railways, of a length of nearly 1,985 miles.

Of course on railways with such difficult curves and gradients, and in a partly mountainous climate, with frequent snow, the carrying on of the traffic

becomes very difficult, and the speed has to be considerably slower than on railways in flat countries. The reduction of speed in Austria has, however, perhaps been made greater than necessary, especially on the Bohemian Moravian, and Lower Austrian lines, where the conditions are more favourable. For instance, we find the speed of the quickest trains in Austria, even over the most favourable districts, nowhere exceeds 28½ miles per hour, while the speeds are for all lines on the average:

25 miles per hour for express trains.
21 miles per hour for passenger trains.
16½ miles per hour for mixed trains.
11¾ miles per hour for goods trains.

The nature of the traffic on Austrian railways differs entirely from that on English lines. The passenger traffic forms only a small portion of the general traffic, and requires only a moderate speed, because its chief purpose is the conveyance of people of inferior civilisation, for whom time is of no value. The immense wealth, however, of the Austrian empire in grain, fuel, ores, timber, wine, and cattle gives rise to a heavy goods traffic, which has to be carried through long distances. In 1870 for example, the Austrian railways carried only 22 millions of passengers, but 22½ millions of tons of goods.

But in Austria the goods traffic also requires less speed than in other countries, as the chief merchandise consists of raw materials, the delivery of which is generally not fixed at a certain time. The consequence is, therefore, that the trains in Austria are much longer and heavier than in England, but that a much smaller number is sent off, and that advantages are offered for conveying with the greater number of trains, passengers and goods, at the same time, because neither passengers nor goods are in a great hurry. The number of these so-called "mixed trains" is 50 per cent. of all trains run. The number of the express trains, as might be expected, is very small in proportion to the total number, and does not altogether exceed 12 per cent. of the latter. During the time of the Vienna Exhibition the number of express trains was increased, but it is only on some of the main lines that two such trains are run daily. Many Austrian lines have no express trains, but convey their passengers with the slow so-called "passenger" and mixed trains. The total number of all the passenger trains on all Austrian railways does not exceed 133 per mile per annum, whilst the corresponding number in England is about 560 per mile. The passenger traffic is therefore in Austria of less importance for the income of the railways than in England; for whilst in the latter country the income from passenger and goods traffic is about as 1 : 1⅓, the receipts from the goods traffic in Austria is 3¼ times as much as that derived from the conveyance of passengers.

Of course these conditions have had a great influence on the construction of the locomotives for the Austrian railways. The engines are, almost without exception, very heavy, and the goods engines, of course, predominate. The various types of locomotives used do not differ so much from each other as in other countries, partly on account of the speed of the various trains being nearly the same, partly because a great number of locomotives of known patterns are obtained from foreign countries, and partly for the reason that the Government commits the mistake of compelling new lines, for the construction of which a concession is granted, to have their engines built after the design of those for older lines.

As a matter of necessity the construction of mountain locomotives was the first and principal duty of the Austrian railway engineers, and in 1858, when the line over the Semmering was completed, a competition was opened for an engine most suitable for working the traffic on this line with long gradients of 1 in 40. The prize was obtained at that time by a locomotive with ten wheels, six of which were placed under the engine, and four under the tender, the front pair of wheels of the latter being also under the engine. All the ten wheels were driven, those under the engine in the ordinary way, by connecting and coupling rods, whilst the moving power was transferred to the tender wheels by means of steel spur wheels keyed to the back axle of the engine and the front axle of the tender. The invention of this construction is attributed to Herr Engerth, who was at that time locomotive engineer of

the Austrian State railways, and whose name has now become famous in connexion with the Great Exhibition at Vienna. The design of these mountain locomotives, however, does not belong by right to Herr Engerth, whose name they bear, but to three of his engineers, Herrn Pius Fink, Fischer Röslerstamm, and Hecker. The spur wheels have, however, long been removed from these mountain locomotives, and the engines, now known as "Engerth's" are of a heavy and inconvenient type in which one tender axle is put under the locomotive. These engines have not been accepted by any locomotive-building people, except in Austria, and on a few French lines.

In Austria, as also amongst some of the German makers, the practice exists of rating locomotives by the horse power they are capable of exerting in ordinary work, and in the year 1870, 1,620 locomotives were being used for the working of 4,270 miles of Austrian railways, only 24 of these engines being rated at a power of less than 100 horses. Of the others,

				horse power.
488	locomotives	were	of between	- 150 and 200
826	,,	,,	,,	- 200 ,, 300
125	,,	,,	,,	- 300 ,, 350

while the remaining number were of more than 350 horse power.

Only half of the above mentioned locomotives were built in Austria, the others having been supplied by England, Germany, and Belgium.

Properly speaking, express engines with one driving axle and large driving wheels, are not in existence in Austria except on the Staatsbahn, which possesses four locomotives with 6 ft. 6 in. driving wheels. Nearly all the Austrian locomotives have four or six coupled driving wheels of a diameter varying from 3 ft. 4 in. to 5 ft. 6 in., but the general diameter is about 4 ft. In nearly all cases the cylinders are outside, and many of the engines, especially those for goods service are constructed on Hall's system, a system of which we shall have to speak in due course.

The fuel used on Austrian railways varies very much; the Bohemian lines burn the excellent brown coal of that country; in Silesia very good pit coal is used, which is almost equal to the English coal; the Sudbahn carries on its difficult mountain traffic with the inferior coal of the Koflacher district; whilst some of the Gallician lines fire still with wood, not because it is the most advantageous fuel for them, but because the nearest forests are the private property of members of their boards of directors. On account of the inferior heating power of most of these fuels, the Austrian locomotives are usually provided with tolerably large fireboxes and grates, the former offering generally a heating surface of from 70 to 90 square feet (English). The grate area, however, is far less than that usually provided in Belgium where inferior fuel has to be dealt with. The quality of the fuel is also the reason why the boilers in Austria are made larger than elsewhere; in Germany for instance, 3·5 square feet of heating surface are taken per horse power, whilst 4·5 square feet is the usual amount in Austria. Partly because the inferior kind of brown coal and the wood really produce more sparks than good fuel, but partly also through custom, the chimneys of Austrian locomotives are invariably provided with spark-catchers. These are constructed on various principles, but none of them fulfil their purpose completely, and all of them are more or less obstructive to the production of steam.

Cast steel is generally used for the axles, tyres, connecting and coupling rods, &c., of Austrian locomotives. Austrian engineers have no hesitation in using for these parts Bessemer steel, which is produced in Austria in good quality from charcoal iron.

Only a proportionately small number of engines are provided with steam counterpressure brakes, but at present they are being nearly everywhere applied, especially to mountain locomotives, where they are of good service. Most of these brakes are constructed on Le Chatelier's system.

The locomotives for working the mountain traffic are many of them of enormous dimensions, for instance, the engines running over the Semmering and the Brenner have mostly a diameter of cylinder of from 18 to 20 in. and a stroke 24 to 25 in.; while their heating surface is from 1,500 to 2,000 square

feet, and their weight from 55 to 65 tons. The diameter of the driving wheels is from 3·3 to 4 ft., and the pressure of steam from 100 to 130 lbs. per square inch.

On account of the import duty on iron, the proportionately little developed Austrian iron and machinery industry, and the inferior working capacity of the people, the prices of the Austrian locomotives are higher than those of English and German make, although taken as a whole they are inferior to the latter both in respect to design and workmanship.

Not much can be said in general regarding the consumption of fuel and lubricating material, or the repairing expenses of the Austrian locomotives. The consumption of fuel cannot be easily compared, as the nature of the material used in the various districts differs too widely. The reduction of the consumption to a minimum is now sought to be obtained on almost all lines, by offering premiums for economy to the drivers and stokers. On the average the large quantity of 3·2 cwt. of fuel is consumed per German train mile (=76 lb. per English mile), but in considering this average, the heavy traffic on the mountain lines, and the low heat-producing capacity of wood, brown coal, and briquettes must be remembered. The engines have to draw for this consumption, in express trains, 6 or 8 carriages; in passenger trains, 10 or 15 carriages; in mixed and goods trains, 30 or 40 wagons. The superintendence over the proper state of service of the locomotives of all railways, and the strength of the boilers, is in Austria carried out by the Government, which has all boilers examined by members of the Court of Revision (Oberauf sichts-behërde), at Vienna.

Passing on now to the engines exhibited at Vienna in the Austrian and Hungarian sections we have first to notice five locomotives constructed at the Maschinenfabrik der k. k. Priv. Staats Eisenbahn Gesellschaft, at Vienna. These works were erected about 33 years ago by Mr. J. Haswell, under whose control they have since been ably conducted. Although belonging to the State Railway Company they occupy a position differing materially from that of any railway works in this country, as they not only turn out engines for the State lines, but compete with other works in constructing locomotives for other railways, and, besides, turn out a variety of general machinery. The works employ about 1,100 hands in the locomotive department, and during the past year upwards of 90 locomotives were constructed at them, rather more than half the number being for the State railways.

An especially interesting feature connected with these works is the system of hydraulic forging which has been so successfully developed by Mr. Haswell; and before describing the locomotives shown at the Vienna Exhibition it may be as well that we should give some particulars of a system which has influenced so greatly the details of their construction. Broadly speaking, Mr. Haswell's system of forging consists in placing blooms, heated to a good welding heat, between dies or matrices, and subjecting them to an enormous hydraulic pressure. Under the influence of this pressure the plastic iron flows into the recesses of the mould, filling them perfectly, and by this system Mr. Haswell is enabled to produce at a moderate cost most complex forms which, if forged by hand, would be most extravagantly costly.

The older hydraulic forging machine in use at the works consists of a strong base plate, or anvil block, connected by four wrought-iron columns, with an overhead hydraulic cylinder 19 Austrian inches (=19$\frac{1}{16}$ in. English) in diameter. This cylinder is of cast iron, strengthened by wrought-iron hoops, and at the top of it is a "drawback" cylinder about 5 in. in diameter, the plunger of which is connected by crossheads and side rods with the plunger of the main cylinder. The small plunger has the water pressure constantly against it, and thus when the water is released from the large cylinder, the small plunger rises, carrying with it the larger plunger to which it is connected. The upper matrix is fixed to the lower end of the large plunger, while the lower matrix is carried upon a small four-wheeled trolly, which runs on rails laid so as to pass between the columns of the press. The platform of the trolly on which the lower mould rests lies between the carrying axles, and is connected to the latter by springs, these springs being of such a strength that the platform, when loaded with the mould, is carried a short

distance clear of the rails. This being the case, the trolly can be traversed freely; but when in its position under the press, the pressure of the plunger on the bloom placed on the lower mould further deflects the springs, and the platform then takes a solid bearing on the bedplate, the strain put upon the axles of the trolly being merely that due to the extra deflection of the springs. The trolly is made long enough to hold two moulds, if necessary, so that one may be used while the other is cooling, and the whole arrangement is a most convenient one.

The water is supplied to the press at a pressure of three tons per square inch by a horizontal pumping engine close by, this engine having its steam cylinder placed at the centre of the bedplate and the piston rod extending out through the two covers and forming the plungers of a pair of pumps fixed one at each end of the bedplate. The slide valve of the steam cylinder just mentioned is moved by a piston working in a small auxiliary cylinder, the slide valve of this latter cylinder being in its turn moved at the end of each stroke of the last piston by arms connected to the rod of the latter coming into contact with stops on the small valve spindle. There are no safety valves on the hydraulic pipes, and the pumping engine moves just as the water is required by the press, being stopped by the resistance opposed to the plunger of the latter when the moulds have been forced home. The steam pressure used is 80 lb. per square inch.

In working the press the plunger with the upper mould is allowed to fall on the bloom by the action of gravity alone, the cylinder filling with water (drawn from an overhead tank) as the plunger falls. As soon as the plunger is in contact with the bloom, however, the water under pressure is turned into the cylinder, and all other water required to cause the descent of the plunger is forced in by the pumps. The opening and closing of the valves for admitting water to, or releasing it from, the hydraulic cylinder, is effected by moving by hand the slide valve of one or the other of two small steam cylinders, the pistons of which are connected to levers for moving the hydraulic valves. The sudden opening or closing of these valves is prevented by their levers being connected to perforated pistons moving in cylinders filled with oil.

It will be seen that, allowing for the reduction of effective area due to the action of the drawback cylinder, the press, of which we have just been speaking, is capable of exerting a pressure of 848 tons, or making a liberal allowance for friction of cup leathers, &c., say 800 tons. With this pressure at his command Mr. Haswell is enabled to forge outside cranks, pistons, axle boxes, eccentrics (a pair of eccentrics being forged solid in one piece), straps for connecting rods, spring buckles, expansion links, and an immense variety of other details, many of them of very complex form, while besides he employs the press for "cogging" or drawing down steel ingots—work which it performs in excellent style — and for other similar operations. Recently, too, Mr. Haswell has commenced forging his wheels in segments under this press, but of the manufacture of wheels as conducted at the works of the States Railway Company we shall speak hereafter.

To explain more clearly the mode of carrying out Mr. Haswell's process of hydraulic forging, we may describe here the mode of stamping a spring buckle having pins projecting from its sides, as shown in Fig. 8, Plate CIX.,* springs fitted with these buckles being placed between the two plates of a compensating beam, as in the case of the eight-coupled engine "Kaiser Franz-Josef," which we shall describe presently. The piles from which these buckles are forged are made of selected scrap, 6 cwt. of this scrap making eight buckles. The pile is first forged under a two-ton steam hammer, and the bloom produced is cut into eight equal parts. These portions, of 84 lb. each, are then placed in a reheating furnace, and brought up to good welding heat ready for stamping. The stamping is performed

* For particulars of the mode of forging this detail, and for the sketches of the moulds, we are indebted to some able articles on hydraulic forging contributed by Mr. Robert Lane Haswell to the *Zeitschrift des Oestereichischen Ingenieur und Architekten Vereins.*

by the aid of two cast-iron moulds of the shape shown in the sketches, Fig. 7 and 8, Plate CIX., A being the upper, and B the lower mould. The lower mould, B, is simply a flat cast-iron slab, having in its centre a hole containing the block *m*, the lower end of which bears upon the base-plate *q*. The block *m*, corresponds in shape with the opening in the spring buckle, but is rather larger than this opening, its width, for instance, being 3·5 in., while the width of the opening in the buckle is but 3·33 in. The upper mould B, has also a hole in its centre, the outline of this hole corresponding with the exterior of the spring box, while recesses are also formed corresponding with the semi-contour of the side pins or studs with which the buckle is furnished. The remaining semi-contour of these pins is formed in loose pieces *e*, fitted to the upper mould, as shown in Fig. 7, these pieces being easily withdrawn, so as to enable the finished forging to be removed.

The two halves of the mould being arranged as shown, the iron, brought to a good welding heat, is dropped into the opening in the mould, and the punch *o*, is then forced down by the hydraulic press. The punch *o*, has a projection *f*, formed on its end, this projection assisting in spreading the iron, so as to properly fill the recesses in the mould, thus forming the side pins or studs. The projection *f*, also serves to form a cavity for receiving and guiding the end of the punch subsequently used. The iron having been pressed, and caused to flow into the cavities in the mould, as shown in Fig. 7, the ram is raised again, and the plug *m*, removed. A loose punch, of a size and shape corresponding with the opening in the spring buckle, is then inserted, and forced through by a second descent of the ram of the press, thus finishing the forging. In this way from 30 to 50 buckles can be stamped by the press in a day of 10 hours. Plain spring buckles, without side studs, are produced in a similar way, but in this case the mould is more simple, there being no loose pieces *e*, and, owing to this, the rate of production is much more rapid, the press turning out from 100 to 120 pieces in 10 hours.

In addition to the older press in use at the works of the State Railway Company, Mr. Haswell in 1873 erected another of still larger dimensions. This new press has a ram two Austrian feet (=24⅞ in. English) in diameter, the cylinder being of cast iron with a thick steel liner. The general arrangement of the new press is similar to that of the older one, but several improvements have been made in details and the construction generally is more massive, so that the machine is fit for exceedingly heavy work. As in the old press the water is supplied at a pressure of three tons per square inch, and we may mention that the supply pipes connecting the press with the pump, have been made by boring out solid Bessemer steel bars, none of the wrought iron pipes obtainable of the required diameter, being found capable of satisfactorily withstanding the pressure. In speaking of the older and smaller press, we mentioned that to avoid waste of power the water required to fill the cylinder after the ram had dropped by the force of gravity was supplied from an overhead tank, and only after the cylinder has been thus filled is water forced in by the pumps. In the case of the new press an overhead tank could not conveniently be provided, but the difficulty has been got over by Mr. Haswell in the following way:—Instead of allowing the water to escape freely from the cylinder of the press during the up-stroke, it is discharged into a cast-iron vessel fitted with an escape valve loaded to a few pounds' pressure above the atmosphere, this pressure being sufficient to overcome the head of water due to the difference of level of the press cylinder and the vessel to which the valve is fitted. When the press plunger falls by gravity, the pressure existing in the vessel just mentioned causes the water to flow back into the cylinder, filling the latter and placing it in the same condition as if it was fed from an overhead tank. The pumps also draw from the vessel of which we have been speaking, and provision is made for replacing any water lost by leakage. By the side of the new press a steam hammer suitable for the preliminary treatment of the blooms has been erected, and when the new plant is fairly at work the old press will be removed from its present position and, with another steam hammer, will be erected in the same shop, which will then contain the finest plant in existence for the production of complex forgings. We may mention, by-the-bye, that

Mr. Haswell makes his steam hammer foundations of concrete, the anvil blocks resting directly on the concrete without the interposition of any timber.

We have spoken at some length on Mr. Haswell's system of hydraulic forging, and our apparent digression from the especial subject of the present section is we think justifiable, not only on account of the great intrinsic value of Mr. Haswell's system, but also on account of the important influence which the employment of that system has exercised upon the construction of the locomotives which it is now our especial object to describe. Thus had it not been for their easy production by the process of hydraulic stamping, Mr. Haswell certainly would not have used wrought-iron axle boxes on his engines, neither would he probably have made his eccentrics of wrought iron and forged them in pairs, while it is probable that numerous other details would have been materially modified. Of the admirable results which can be produced by the hydraulic forging process, the details of the engines exhibited afforded sufficient evidence, while the large number of examples of forgings of all classes which we have had an opportunity of examining at the works of the Austrian State Railway Company have convinced us of the certainty with which the results can be produced.

Before leaving this part of our subject, we may mention here an arrangement which Mr. Haswell has adopted for enabling his presses to be worked with a boiler of moderate dimensions. Naturally in an arrangement of this kind the demand for steam is very unequal; and when a press is employed for drawing down steel ingots, there is especially a large demand during the time a bloom is being treated. To meet this demand Mr. Haswell employs a boiler of the locomotive type, but places above it a second barrel about 4 ft. in diameter, this barrel being connected to the boiler proper by large vertical tubes. Before the cogging or drawing down of a steel ingot commences, the feed water is pumped up so that it not only fills the boiler proper, but also a considerable portion of the upper barrel; but as soon as the press is set to work the feed is shut off, and the water level is allowed to work down. On an ingot being finished the water is pumped up again, and so on. The large quantity of heated water thus stored in the boiler at the commencement of a cogging operation, may be said to occupy the place of a flywheel in a rolling mill, acting as a reservoir of power, and tending to reduce the work to be done by the boiler to an average quantity. We have said that the boilers employed are of the locomotive type; but they are provided with enormously long fireboxes, so as to obtain a large grate area for the efficient combustion of the brown coal which forms the ordinary fuel. In the case of the boiler which has been erected for working the new press the firebox is probably about 9 ft. long, and the crown is corrugated transversely, the corrugations being about 1 ft. deep, and about 2 ft. apart from centre to centre. This form of crown has been adopted both for the purpose of obtaining efficient resistance to compression without the use of roof stays, and also to cause a kind of reverberatory action, and effect a thorough commingling of the combustible gases and air. The arrangement promises to give good results.

We must now, before proceeding with our account of the exhibited locomotives—and at the risk of being taxed with another digression—say a few words respecting the system of manufacturing locomotive wheels adopted by Mr. Haswell. The leading feature of the system as at present conducted at the works of the Austrian State Railway Company, consists in the bosses being formed by welding up the inner ends of the spokes only, no washers being welded on at the sides to make up the thickness of the boss as is the usual practice. The operation of welding up the boss is performed by Mr. Haswell in the following way:—The spokes having been built up into a wheel as usual, and secured by a hoop placed round them, a welding heat is taken on their inner ends, and the boss is then laid in a die formed as shown at A, in the sketch Fig. 9, Plate CIX. This die is hollowed to fit the boss, and its rim is notched out to receive the spokes, the remaining portions of the rim forming, as it were, a series of fingers which reach up between the spokes, and prevent the spreading of the boss outwards. Next a mandril B is dropped into the hole in the boss, and then the upper die C, which is

of a similar form to the lower die A, is forced down by the pressure of 80lb. steam on the upper side of a piston about 3 ft. 6 in. in diameter, working in an overhead steam cylinder. The upper die C is attached to the piston rod D by a loosely-fitting cotter E, and after the die has been forced down as described, the cotter is withdrawn, the piston raised, and then made to perform a quick down stroke, the piston rod then acting as a ram, and giving a sharp blow to the upper die.

The welding of the boss, effected in the manner above described, is perfectly sound, and in none of the bored and turned wheels which we had an opportunity of examining at Mr. Haswell's works was any sign of a faulty weld to be seen. The spokes for the wheels are for the most part stamped separately in the hydraulic forging press; but Mr. Haswell was at the time of our visit introducing another mode of manufacture, which he intended to adopt almost exclusively as soon as the new and more powerful forging press was fairly at work. According to this plan, instead of each spoke being forged separately, the wheels are made in segments, each segment consisting of two spokes with the corresponding portions of the boss and rim as shown in the sketch Fig. 11, Plate CX. These segments are stamped out in one solid piece in the hydraulic forging press, and they are built up and treated just as the separate spokes. With the segments, however, the number of welds in the rim and boss is reduced to one-half, and all welds between the spokes and rim are done away with. Mr. Haswell was, as we have stated, already successfully stamping out segments of this kind in the older forging press at the time of our visit, and altogether this mode of constructing wheels is one which promises to give exceedingly good results.

We must now proceed with our description of the engines constructed at the works of the Austrian State Railway Company, which were shown at the Vienna Exhibition, and we shall commence with the locomotive "Austria," of which we give outline engravings in Figs. 3 and 4, Plate CX.

Passenger Locomotive "Austria," by the Austrian State Railways Company.—This locomotive is constructed on the Engerth system, and was the only inside cylinder engine in the Exhibition. As will be seen from the illustration, the front end of the engine is carried on four coupled wheels 5 ft. 2 in. in diameter, these wheels being placed 8 ft. $7\frac{3}{4}$ in. apart from centre to centre. The hind part of the engine or tender is carried on three pairs of wheels 3 ft. $1\frac{1}{4}$ in. in diameter, these wheels having a total wheel base of 11 ft. $4\frac{7}{8}$ in. The frames of the tender extend past the sides of the firebox and are connected by cross stays to a coupling pin under the barrel of the boiler between the firebox and the driving axle, this arrangement, by which the weight of the firebox is supported by the tender frame, forming, as is well known, the distinctive feature of Herr Engerth's system. The total wheel base is 27 ft. $3\frac{1}{2}$ in.

The engine has cylinders $16\frac{3}{16}$ in. in diameter with 1 ft. $10\frac{13}{16}$ in. stroke, and the guide bars—of which there is a pair for each cylinder situated above the level of the centre line of the latter—are round, and are embraced by glands carried by the crosshead, an arrangement which we cannot say we like. The steam pipes, it will be noticed, are led down outside the smokebox. The link motion is of the ordinary Stephenson type, and the engine is provided with screw reversing gear. The axle box guides for the coupled wheels are fitted with adjusting wedges. The boiler bariel is 4 ft. $3\frac{1}{4}$ in. in diameter inside the largest ring, and 13 ft. $10\frac{1}{8}$ in. long between tube plates. The thickness of the barrel plates is $\frac{7}{16}$ in. We may mention here that at the works of the State Railway Company all boiler plates are bent hot, while all rivet holes (except those in flanged plates) are punched, and the rivetting is done by hand, the longitudinal—and in some cases both longitudinal and transverse—seams being double rivetted. The engine now under notice, like most Austrian locomotives, has a very large dome, and it will be noticed that the barrel is strengthened at the opening made in it by the plate being flanged inwards, as shown, an excellent mode of providing additional strength at openings in boiler barrels which Mr. Haswell adopts in all engines made by him. The top of the dome as well as the mud collector under the barrel are stamped in the hydraulic forging press of which we have

already spoken, the bottom of the mud collector being, as will be seen, flanged inwards so as to form a kind of lip for holding the india-rubber packing used in making the joint.

The boiler contains 179 tubes, $2\frac{1}{16}$ in. in diameter outside and 13 ft. $10\frac{7}{8}$ in. long between tube plates, these tubes exposing an external surface of 1345 square feet. The firebox surface is 87 square feet, the engine thus having a total heating surface of 1432 square feet. The fire-grate area is 18·8 square feet, and the boiler is worked at a pressure of nine atmospheres effective = 132·3 lb. per square inch. The weight of the engine empty is $36\frac{1}{4}$ tons, and in working order 50·3 tons, this latter weight being distributed as follows :—On leading wheels 10·9 tons, on driving wheel 13·15 tons; on third pair of wheels 9 tons; on fourth pair of wheels 8·8 tons, and on trailing wheels 8·75 tons. An ordinary screw brake is applied to the two hind pairs of wheels, and the engine is also fitted with Chatelier's counter-pressure arrangement. The total length of the engine over all is 38 ft. $5\frac{5}{8}$ in., while the maximum width is 9 ft. $7\frac{1}{2}$ in., and the height 15 ft. $2\frac{1}{2}$ in. Locomotives of the type of which we have been speaking have been in use on Austrian lines since 1856.

Goods Locomotive "Kaiser Franz Joseph," by the Austrian State Railways Company.—The next engine of which we have to give particulars is the "Kaiser Franz Josef," an eight-coupled outside cylinder engine, of which we give outline engravings in Figs. 9 and 10, Plate CX. This engine is of a type introduced in 1867, and the particular locomotive shown was constructed in 1870, since which time it had been running on the lines of the Austrian State Railway Company, by the traffic directors of which company it was exhibited. We may mention also that it was the 1000th locomotive turned out at the works of the company, and was constructed exclusively of Austrian materials. The engine has cylinders $18\frac{1}{2}$ in. in diameter with $24\frac{7}{8}$ in. stroke, and the piston rods are carried through the front cylinder covers, brass casings being provided to prevent an engineman from placing his foot upon the rod in getting up at the front of the engine. The valve gear is inside, and is of the stationary link type, the eccentric rods being bent to clear the second axle, as shown. The wheels—all coupled— are 3 ft. $10\frac{1}{16}$ in. in diameter, and the total wheel base is 12 ft. $5\frac{3}{8}$ in. The trailing axle, however, is allowed side play in the axle boxes, and the length of rigid wheel base is thus reduced to 9 ft. 2 in. The hind length of each set of coupling rods is made with a long forked end, and is connected to the other lengths by two pins, as shown in the plan. Of the two pins, that next the driving crank pin is fitted in the usual way, while the other passes through an elliptical hole, of which the longer diameter is vertical, the hind end of the rod being thus at liberty to play up and down through a limited range, while the long fork and the two pins keep it rigid laterally. The trailing crank pin is, of course, made longer than the width of the coupling rod bearing, so as to permit of the trailing axle moving laterally without putting a strain on the coupling rods. This arrangement has for some time been in common use on Austrian railways and it is found to answer well.

The driving and trailing axle boxes of the engine under notice are connected by compensating beams, these beams being each made of two plates having the spring arranged between them. The leading springs are also connected at their front ends by a compensating beam which extends across the engine, connecting the spring on one side with that on the other. A central support is thus obtained at the leading end. The engine has inside frames formed of two thin plates with distance pieces between them, and the axle box guides are provided with adjusting wedges, these wedges being made narrow and being arranged between the two plates of the frame. Each wedge thus acts between a distance piece bolted between the frames and the adjoining axle box guide, an arrangement which is very neat and simple.

The boiler is similar in construction to that of the engine last described, the barrel, however, being very large, the diameter inside the largest plate being 4 ft. 7 in. The thickness of plates is $\frac{5}{16}$ in. The boiler contains 207 tubes, $2\frac{3}{4}$ in. in diameter outside and 16 ft. $5\frac{3}{16}$ in. long between tube plates, these tubes giving an external heating surface of 1,836·3 square feet. The

firebox heating surface is 105·5 square feet; thus making the total heating surface 1,941·8 square feet. The firegrate area is 21 square feet, and the boiler is worked at a pressure of 9 atmospheres effective, or 132·2 lb. per square inch.

The engine is 31 ft. $\frac{5}{8}$ in. long over buffers, by 9 ft. $\frac{7}{8}$ in. in width and 15 ft. $2\frac{3}{8}$ in. in height, and it weighs light 39 tons, and in working order 44·35 tons, this latter weight being distributed as follows:—On leading wheels 11·3 tons, on second wheels, 10·8 tons, on driving wheels 11·15 tons, and on trailing wheels 11·1 tons. Both this and the engine last described have roomy footplates protected by neat cabs, and the "Kaiser Franz Josef" is also provided with self-acting sand boxes having valves opened from the footplate. In the case of the "Austria" the sand boxes are fitted with screws which can be turned by the driver, the delivery of the sand taking place only when the screws are thus turned.

Tank Locomotive "Hungaria," by the Austrian State Railway Company.—The next locomotive on our list is a small tank engine constructed at the works of the Austrian State Railway Company for a line of three Austrian feet (3 ft. $1\frac{6}{10}$ in. English) gauge connected with the Reschitza Iron Works. Of this engine, which is named the "Hungaria," and which was exhibited in a pavilion situated between the Machinery Hall and the Industry Palace, we give outline views in Figs. 7 and 8, Plate CX. From the views there given it will be seen that the engine has four coupled wheels, these wheels being 2 ft. 4 in. in diameter, and being placed at a distance apart of 4 ft. 8 in. from centre to centre. A special feature in the engine is the mode of guiding the axle boxes, the arrangement being one designed and patented by Mr Haswell. According to this plan the two axle boxes of each axle are connected by plates attached to them and extending from one box to the other parallel to the axle. Each of these plates carries at its centre a pin or stud which enters a block moving in guides fixed to cross-stays extending from frame to frame as shown in the plan. With this arrangement the axles are prevented from moving laterally by the guides fixed to the cross-stays; but at the same time they are left quite free to tilt (except so far as the tilting is restrained by the action of the springs), the axle boxes being without flanges, and the ordinary axle box guides thus only serving to keep the axle boxes steady and to prevent motion in the direction of the length of the engine. The springs have a curved bearing on the axle boxes, and the spring links are made with spherical joints, so that the axle boxes are at all times left free to take a fair bearing on the axle journals. This mode of mounting the axle boxes possesses several very good points, it, amongst other things, greatly relieving the frames of twisting strains, and we understand that in practice it answers admirably.

The "Hungaria" has outside cylinders $9\frac{4}{10}$ in. in diameter, with $12\frac{4}{10}$ in. stroke, and the link motion is also outside, the gear being of the Allan, or straight link type. The eccentric rods are of round section, as are also the connecting and coupling rods, the latter as well as the connecting rods being fitted with strap ends. The boiler is placed rather high, and the firebox extends but a comparatively short distance below the barrel, the object being to allow the firebox to extend out over the frames and thus to obtain readily the large firegrate area required for successfully burning the brown Austrian coal. At first sight engines with boilers thus raised appear topheavy; but Mr. Haswell justly argues that there is no more danger in carrying a boiler at this height mounted on its own wheels, than there would be in conveying it on a waggon, and in practice no inconvenience is experienced, the engines running very steadily, a result no doubt due to a considerable extent to the arrangement of springs and axle box guides of which we have already spoken.

The boiler of the engine under notice has a barrel 2 ft. $7\frac{1}{8}$ in. diameter inside the largest plate, and 6 ft. $4\frac{3}{4}$ in. long between tube plates. The barrel plates are $\frac{3}{8}\frac{3}{4}$ in. thick and the boiler is worked at a pressure of 10 atmospheres effective or 147 lb. per square inch. The firebox, which is of copper, is constructed on a system introduced some years ago by Mr. Haswell, and which is not only being extensively used by him, but by other continental

makers also. According to this plan the firebox is made with a semicircular crown, the plate forming the sides and crown of the box being corrugated as shown. The corrugations are about an inch deep and $6\frac{1}{2}$ in. wide from centre to centre. These corrugations together with the arched form of the crown render the box perfectly capable of resisting the external pressure without being strengthened by roof stays; but as an additional security a row of sling stays is placed along each side and coupled to the crown about midway between the sides and centre line. These stays are, however, left quite slack, and are only intended to come into use in the event of the crown becoming distorted by overheating. The sides of the box are stayed as usual, except that the additional stiffness obtained by the use of the corrugations permits of the stays being placed at about $6\frac{1}{2}$ in. centres instead of about 4 in. centres as is usual. We may mention that all the firebox stays used by Mr. Haswell are of copper, and have a small hole right through them, this hole being either formed by drilling the stays, or copper drawn hollow—very thick copper tubes in fact—being used in making them. We may add that the corrugations in the firebox side and crown plates are formed by hand hammering, the edges of the plates being left flat to join the flanges of the front and back plates, and the firebox ring respectively.

The boiler of the "Hungaria" contains 54 tubes, $2\frac{3}{4}$ in. in diameter outside, and 6 ft. $4\frac{3}{4}$ in. long between tube plates, these tubes thus exposing an external surface of 183 square feet. The firebox surface is 24·4 square feet, thus making the total heating surface 207·4 square feet. The firegrate area is 7·5 square feet. The water is carried in a kind of inverted saddle tank placed on the top of the frames and beneath the boiler, this tank holding 198 gallons. The coal bunker, which will contain about 6 cwt. of coal, is situated on one side of the firebox, the corresponding space on the other side being left clear for the driver. The footplate is protected by a neat cab. The weight of the engine light is 9.05 tons, and in working order 11.5 tons, this weight being equally distributed between the two pairs of wheels. The engine has wooden buffer beams and central buffers, and the total length over buffer beams is 14 ft. $7\frac{3}{8}$ in., while the maximum width is 6 ft. $4\frac{3}{4}$ in., and the height 10 ft. $1\frac{3}{8}$ in. The workmanship of this engine, as also of the other engines constructed at the works of the Austrian State Railway Company, was very good.

Goods Locomotive "Stainz" by the Austrian State Railway Company.—The locomotive "Stainz," of which we give outline engravings in Figs. 5 and 6, Plate CIX., is another engine constructed at the works of the Austrian State Railway Company on Mr. Haswell's plan, this engine having six-coupled wheels 3 ft. $6\frac{3}{8}$ in. in diameter, and a wheel base of 9 ft. $4\frac{1}{8}$ in. The cylinders are outside and are $15\frac{9}{10}$ in. in diameter with 2 ft. $0\frac{7}{8}$ in. stroke, the piston rods being continued through the front covers. The valve motion is also outside, and is of the Stephenson type, the eccentric rods being very long. The eccentrics are of wrought iron, the pair for each side being forged in one piece. The axle boxes are guided as in the engine last described, and the springs for the leading and central axles are connected by compensating beams, as shown.

The boiler, like that of the "Hungaria," is constructed with a shallow firebox, and with the crown formed of an arched corrugated plate, the firebox being kept above the level of the frames, as shown, so as to obtain a wide grate. It will be noticed from the views we publish, that the boiler is supported at the firebox end by links hinged to the frame, so that it is quite free to expand longitudinally. A special feature connected with the boiler is the large mud collector with which it is provided, this mud collector, being fitted with a blow-off cock or valve of a rather peculiar kind. This blow-off cock consists of a valve opening inwards, the spindle of the valve being prolonged downwards and attached to a piston moving in a small steam cylinder placed as shown in the longitudinal section. By simply admitting steam below this piston the blow-off valve is raised, and this operation can be readily performed when the engine is running. The pipe which conducts away the discharged water and mud is fitted with a cock, so that in the event of any sediment getting under the steam-worked valve, and preventing it from

closing, this cock can be shut. This arrangement of blowing-off apparatus has been designed for use on a line where very bad water has to be used, and where very frequent blowing off is a necessity.

The boiler of the "Stainz" is worked at a pressure of 10 atmospheres effective, or 147 lb. per square inch, and the barrel, which is composed of $\frac{7}{16}$ in. plates, is 4 ft. 5 in. in diameter inside the largest ring, and contains 183 tubes, $2\frac{3}{4}$ in. in diameter and 10 ft. $3\frac{1}{8}$ in. long between tube plates. These tubes expose an external heating surface of 1,030 square feet, making with 84 square feet of firebox surface, a total heating surface of 1,114 square feet. The firegrate area is 21·5 square feet.

The weight of the engine empty is $28\frac{1}{4}$ tons, and in working order 32·2 tons; 10·3 tons of this weight being on the leading wheels, 10·25 tons on the centre wheels, and 11·65 tons on the trailing wheels. The engine is provided with two sand boxes on each side, one delivering sand in front of the leading wheels, and the other in front of the trailing wheels; these sand boxes being fitted with the screw delivering apparatus, of which we have already spoken. The total length of the engine over buffers is 24 ft. $10\frac{7}{8}$ in., the maximum width 9 ft. $6\frac{1}{8}$ in., and the height to top of chimney 14 ft. $8\frac{3}{8}$ in.

Goods Locomotive "Orient," by the Austrian State Railway Company.—The last engine of Mr. Haswell's which we have to notice here is the "Orient," a locomotive specially designed by him for traversing sharp curves and doing heavy work on a line of one metre (3 ft. $3\frac{3}{8}$ in.) gauge. As will be seen by the outline engravings, Figs. 5 and 6, Plate CX., this engine has eight coupled wheels 2 ft. $4\frac{3}{8}$ in. in diameter, the total wheel base being 7 ft. $10\frac{1}{2}$ in. The trailing axle, however, has an end play in the axle boxes of $1\frac{3}{8}$ in., and the rigid wheel base is thus reduced to the distance between the centres of the first and third axles, or 5 ft. 3 in. The axle boxes are connected and guided in the same manner as those of the "Hungaria" and "Stainz" already described, and the springs of the first and second pairs of wheels and those of the third and fourth pairs are connected by compensating beams, while a transverse compensating beam is also provided beneath the ashpan to connect the hind ends of the two trailing springs.

The cylinders are outside, and are $13\frac{3}{4}$ in. in diameter with $12\frac{7}{16}$ in. stroke, while the valve motion is also outside, and is of the Stephenson type. The engine is fitted with Chatelier's counterpressure arrangement. As on the "Stainz" the boiler is placed rather high, so that the firebox is kept clear above the frames, and this arrangement causes the axle boxes, springs, and running gear generally to be very easily accessible. The barrel of the boiler is 3 ft. $8\frac{1}{8}$ in. in diameter and is made of plates $\frac{3}{8}\frac{1}{4}$ in. thick, the working pressure being very high, namely 12 atmospheres effective or $176\frac{1}{2}$ lb. per square inch. The barrel is fitted with a large mud collector and steam worked blow-off cock similar to that already described when speaking of the "Stainz." The boiler contains 102 tubes, $2\frac{3}{4}$ in. in diameter and 7 ft. $10\frac{1}{2}$ in. long between tube plates, these tubes exposing an external heating surface of 430·6 square feet. The firebox casing is long, namely 5 ft. $1\frac{3}{8}$ in., and the firebox surface is thus large, being equal to 64·6 square feet, and the total heating surface is thus 495·2 square feet. The firegrate area is 15 square feet.

The total weight of the engine light, is 18 tons, and in working order 20 tons, distributed equally on the four pairs of wheels. The total length of the engine over buffers is 20 ft. $3\frac{3}{8}$ in., the maximum width 7 ft. $5\frac{3}{4}$ in., and the height to top of chimney 11 ft. $5\frac{3}{4}$ in. There can be no doubt that in the "Orient" Mr. Haswell has produced a very powerful engine with a moderate weight. The "Orient" was shown in the Machinery Hall, accompanied by a four-wheeled tender of a simple type, the fuel being carried on the top of the tank. The tender tank, like the tank of the "Austria" already described, is fitted with a gauge glass for showing the level of the water, this glass being suitably protected. As we have already remarked the workmanship of all Mr. Haswell's engines was excellent, and the painting was particularly good.

Express Locomotive for the Southern Railway of Austria, by G. Sigl, Wiener-Neustadt.—Mr. G. Sigl exhibited in the Austrian section of the Machinery

Hall four locomotives constructed at his works at Wiener-Neustadt, and of these we shall first describe the "Rittinger," an express locomotive, of which we give a perspective view on Plate CXI., and which also forms the subject of Plates CXII. and CXIII. For the principal dimensions of the "Rittinger," we refer to the tabular statement which accompanies the plan of the engine on the last-mentioned Plate, while our engravings show the general construction so fully that we merely propose here to direct attention to some special points connected with the design.

The "Rittinger" is an example of a type of engine which is at present regarded with considerable favour on a number of Continental lines. It has outside cylinders and outside frames, and is built upon the Hall system, the cranks, however, being completely outside the axle bearings. Of course this arrangement leads to a very wide engine—the "Rittinger" is 9 ft. 9⅛ in. wide over cylinder flanges—but on Continental lines generally a much greater width is admissible than with us, and this feature therefore is not regarded as objectionable.

The valve chests are placed over the cylinders, the valve faces being inclined downwards towards the hind end, and the valve motion is placed close to the outside of the frame, the eccentrics being forged solid on the bosses of the driving cranks. This makes a very neat job, and if outside cranks are used at all it affords probably the best way of dealing with the eccentrics, as we regard it as far preferable to mounting the eccentrics on a return crank, and putting the valve motion outside everything. In the "Rittinger," it will be seen that the expansion links give motion to a "dummy" valve spindle, working in "diamond" guides, and provided with an arm, forged solid with it, which gives motion to the valve spindle proper. The whole arrangement is clearly shown by the plan, Plate CXIII.

The bogie at the leading end of the engine is of the ordinary four-wheeled type, and swivels upon a fixed centre carried by cross-stays secured to the main frame. The weight, however, is not transmitted to the bogie through the centre, but through a pair of side bearing plates. The bogie is substantially framed, and the arrangement of the engine gives ample room for the spring gear, &c.

With outside frames only the great width between the frames renders it difficult to effect that rigid transverse connexion which is so necessary to maintain squareness, and this is particularly the case when, as in the "Rittinger," the presence of a bogie interferes with the introduction of stays at the leading end. In the engine under notice, the bottom of the smokebox is made of double plate, and this and a heavy cross-stay (formed by carrying down the front plate of the smokebox), about 6½ in. behind the leading buffer beam are employed to give tolerable rigidity at the leading end. The other cross-stays for the frames are, as will be seen from our illustrations, both few and of very light sections.

Each axle has independent springs, there being no compensating gear. The guides for the axle boxes of the coupled axles are provided with adjusting wedges, the arrangement of these wedges being similar to that to which we have before referred as being employed by Mr. Haswell. Thus referring to the plan and longitudinal section, it will be seen that the frames, which are double, have bolted between them a cast-iron block, a short distance from each hind rubbing piece, or guide, for the driving and trailing axle boxes. This block is placed obliquely, and the wedge is dropped down between it and the rubbing piece, the latter having oval holes through which the bolts securing it pass, so that it can be set up by the wedge as wear takes place. The axle boxes are of wrought iron, and the rubbing pieces of cast iron.

The boiler, which is double rivetted, has the crown of the fire-box casing raised above the level of the barrel, a peculiarity in the construction being the introduction at the junction of the upper part of the firebox casing and the barrel of the series of T-iron stays shown by the longitudinal section. We cannot but regard these stays as unnecessary. The firebox crown is stayed by the ordinary girder stays assisted by sling stays.

The general fittings of the engine under notice are very neat, while the workmanship is excellent, and most creditable to Mr. Sigl. The footplate is,

as will be seen, protected by a neat cab, but if reference be made to the perspective view which is given on Plate CXI. it will be seen that no footplate is carried along the side of the engine. This absence of a footplate is not at all uncommon on the Continent, and no doubt, where the stoppages are so frequent, the want of the means of going forward on the engine is scarcely felt. We need scarcely add, however, that the system would not answer in this country, where express trains make runs of over two hours without stopping.

Goods Locomotive for the Royal Hungarian Railways, by G. Sigl, Wiener-Neustadt.—Next on our list of Mr. Sigl's locomotives is the light-coupled engine intended for mountain service on the Royal Hungarian Railways, which forms the subject of Plates CXIV., CXV., and CXVI., while a perspective view of it is also given on Plate CXI. As will be seen from the engravings, this locomotive is a fair specimen of the type of heavy eight-coupled engines constructed on Hall's system, which has found so much favour in Austria and Southern Germany, and although the type is one which, for reasons we have before pointed out, we do not ourselves admire for heavy mountain service, yet the fact of its extensive adoption renders it undoubtedly well worthy of the examination of English engineers.

The distinguishing features of this type are :—Outside cylinders and frames, with outside cranks, on the bosses of which the bearings are formed ; a short wheel base with lateral traverse allowed to the trailing axle ; and a long boiler with barrel of large diameter containing a number of tubes, the result being a very large proportion of tube surface to direct fire-box surface. With the soft and inferior coal in use on the Austrian and Hungarian lines we should regard a large fire-grate area, and an unusually large proportion of direct fire-box heating surface as absolutely essential to economical working ; but it will be seen on reference to the table of dimensions appended to Plate CXVI., that these conditions can scarcely be considered to be satisfied in the engine under notice. The fire-grate area and firebox are, it is true, large in the abstract, but when compared with the total surface, they will be seen to be far below the proportions given in this country even for a far better kind of fuel. Thus in the engine we illustrate the fire-grate and total heating surfaces are as 1 to 89·6, while the firebox surface forms but 5·46 per cent. of the total heating surface. The Hall system with outside frames undoubtedly possesses the advantage of allowing the use of an increased width of fire-box ; but we nevertheless cannot consider it desirable that locomotives intended to traverse sharp curves should have their axles coupled by outside cranks, and we believe that the experience gained on the Southern Railway of Austria supports our view of this matter. At all events the latest type of eight-coupled locomotives for working the Semmering and the Brenner traffic on the last-mentioned railway are being built with inside frames, notwithstanding that formerly the outside framed Hall engines were employed.

The various details of the locomotive under notice are shown so clearly in our engravings that but a brief description will be necessary. The boiler, which is double rivetted, is made with a raised fire-box casing, the junction between the latter and the barrel being stiffened by ⊥-iron corner stays, as shown in the longitudinal section. The firebox crown is strengthened by the ordinary longitudinal girder roof stays, these stays being supported by sling stays, and being connected at their ends to the longitudinal stays extending to the back plate of firebox and the smokebox tube plate. The great length of the tubes we have already commented upon. As in many of the Continental locomotives intended for slow service, the chimney is made of cast iron, while the bottom of the smokebox also consists of a casting shaped so as to form a hopper for the convenient discharge of ashes. The blast nozzle is variable, and beneath it there is arranged a grating for arresting sparks, this grating extending right across the smokebox.

The axles are all arranged under the barrel of the boiler, the trailing axle being allowed a lateral traverse of 1·2 in., and the two central axles being connected by compensating beams. The trailing axle and crank-pin bearings are made sufficiently long to permit of the side play, while the trailing lengths of

the coupling rods are connected to the next lengths by long forked ends traversed by two bolts, as shown in the side elevation and sectional plan. The smaller of the bolts passes through a hole, which is elongated vertically, and thus, while a certain amount of flexibility in a vertical plane is retained for the joint between the two lengths of coupling rods, lateral stiffness is secured. We have before spoken of this arrangement.

The main frames are each composed of two plates placed a short distance apart with distance pieces between them. The axlebox guides are all fitted with adjusting wedges. The lateral connexions between the frames appear to us to be very insufficient, and this is particularly the case at the leading end, where, besides the buffer beam, the connexion consists solely of some light plates and angle irons making up the bottom of the smokebox, and a thick plate situated beneath the valve chests, and bolted to them as shown. When the large diameter of the cylinders and their great distance apart is considered, it seems to us inevitable that with such slight transverse connexion, "working" of the frames must soon take place. The cylinders themselves are well fixed to the frames as shown. The piston rods are extended through the front cylinder covers, and the slide valves are of the Haswell or Trick pattern, giving a double opening for the admission of steam. This form of valve is, as we have already stated, one which we believe might be advantageously introduced into English locomotive practice.

As in the case of several locomotives already described by us, the joints between the boiler and fittings are made by the use of brass "lenses," another feature of foreign locomotive practice, to which we have previously alluded as worthy of special notice. The boiler is fed by a pair of injectors with fixed nozzles and arranged below the footplates, as shown. The valve gear is of the shifting link type, with screw reversing gear, and the engine is fitted with Le Chatelier's counter-pressure brake apparatus. It is also provided with self-acting sandboxes worked from the footplate, while the latter is protected by a neat cab. As we have already stated, however, the general details of the engine are very clearly shown by the illustrations, and will be readily understood without further explanations, and we need merely say in conclusion, therefore, that the engine exhibited at Vienna was very well built, the general finish being very creditable to Herr Sigl.

Goods Engine (Second Class) for the Royal Hungarian Railways by G. Sigl, Wiener-Neustadt.—Besides the powerful engine last described, Mr. Sigl also showed in the Machinery Hall a six-coupled engine of a lighter type also intended for service on the Hungarian State Railways, this engine being constructed on Hall's system, with outside cylinders, outside frames, and outside cranks on the bosses of which the bearings are formed. The valve gear is inside, and is of the shifting link type. The cylinders are 13·6 in. diameter with 22·8 in. stroke, and the wheels 3 ft. 10½ in. in diameter, with a wheel base of 9 ft. 10⅛ in. The springs of the driving and trailing wheels are connected by compensating beams. A special feature in this engine is an arrangement provided for lubricating the flanges of the leading wheels, and thus facilitating the passage round curves. This arrangement consists of a kind of light iron casing fixed to the box of each leading spring, and shaped so as to form a guide for holding a cake of hard tallow or equivalent lubricating material, this cake being about 3 in. wide by ¾ in. thick, and being wrapped in a metal foil. The guide just mentioned is so shaped that the lower end of the cake of lubricating material is directed against the outer edge of the flange of the leading wheel at an angle of about 45 deg., the weight of the cake causing it to bear lightly against the flange.

As the wheel revolves, the flange, of course, rubs off a supply of lubricating material from the bottom of the cake, the latter sliding down its guide as it wears away. It appears to us that a cake of lubricating material applied in this way must be subjected to very rapid destruction; but we have no data relative to the practical working of the arrangement. The engine of which we are now speaking has a boiler 3 ft. 3⅜ in. in diameter containing 101 tubes, 2·05 in. in diameter outside and 12 ft. 1·7 in. long between tube plates. The external tube surface is 656·6 square feet, and the firebox surface 55 square

feet, or 711·6 square feet in all, while the firegrate area is 9·4 square feet, and the boiler pressure 8½ atmospheres effective, or 125 lb. per square inch. The weight is 20 tons empty, or 22 tons in working order, this latter weight being equally distributed on the three axles. The engine generally is well finished, and the details are neat.

The tender belonging to the engine just described was not exhibited, but we may state that it is of a four-wheeled type, the wheels being 3ft. 3⅜ in. in diameter and placed with a wheel base of 6 ft. 1 in. The tender carries 1,320 gallons of water, and has a fuel space with a capacity of 159 cubic feet, while its weight is 8½ tons empty or 18 tons landed.

Goods Locomotive for the Southern Railway of Austria by G. Sigl, Wiener-Neustadt.—The largest of the locomotives exhibited by Mr. Sigl was the eight-coupled engine constructed for the Oesterreichische Sudbahn, or Southern Railway of Austria, of which a perspective view is given on Plate CXI. The cylinders, which are outside, are 19¼ in. in diameter with 24 in. stroke the piston rods being carried through the front covers, and the wheels, all coupled, are 3 ft. 7½ in. in diameter, while the wheel base is 11 ft. 8½ in., the trailing axle having, however, some side play. The valve motion, which is of the Stephenson type, with box link, is outside, and is provided with screw reversing gear. The frames are inside, with the springs above them, and the spring pins for the trailing axle boxes bear against the underside of a transverse compensating beam which extends out laterally beyond the frames, and thus enables the trailing springs to be spread wider apart so as to clear the firebox. This is an arrangement to which we have previously alluded, and which has long been in use on the Continent; it is an expedient which may be conveniently adopted in many instances. The boiler of the engine under notice is very large, the barrel being 4 ft. 11 in. in diameter, and containing 205 tubes 2 3/4 in. in diameter outside and 15 ft. 7½ in. long between tube plates. These tubes give an outside surface of 1,704 square feet, while the firebox surface is 115 square feet, making together a total heating surface of 1,819 square feet. The grate area is 23·24 square feet, and the boiler is worked at a pressure of 9 atmospheres effective, or 132·3 lb. per square inch. Amongst the minor details we may mention that the sand box is in this engine placed between the frames just behind the smokebox, the sand being delivered through valves worked from the footplate. The engine also, like many others exhibited, is provided with a small pipe leading from the delivery clackbox on one side of the boiler to the smokebox, this pipe, which is furnished with a cock, enabling water to be discharged into the smokebox for the purpose of extinguishing any fire arising from fuel being drawn through the tubes when working with a sharp blast. The weight of the engine is 44¼ tons empty, or 51 tons in working order, the weight being distributed as follows: on first pair of wheels 12½ tons, on second pair of wheels 12½ tons, on third pair of wheels 13 tons, and on trailing wheels 13 tons. The connecting rod, coupling rod, and other bearings about this engine are of white metal, and the parts generally are well proportioned, and adapted for heavy service.

Passenger Locomotive for the North-western Railway of Austria, by G. Sigl, Wiener-Neustadt.—Leaving the Machinery Hall for the present, we have next to speak of another engine constructed by Mr. Sigl, which was exhibited by the Oesterreichische Nordwestbahn, or North-western Railway of Austria, in an admirable model station which the Company had erected near the eastern end of the machinery hall. This building, by the way, represented a regular station, with booking office, waiting rooms, electric telegraph, signal gear, &c., while close to it were put down examples of switches and crossings, a weighbridge, examples of barriers for level crossings and other adjuncts of stations all properly arranged. Within the station building were examples of rolling stock with an engine and snow-plough, and altogether the exhibition was a most complete and interesting one. In the electrical apparatus particularly there were several objects of special interest, but these we must leave for notice in their proper place. The engine shown in this station was built by Mr. Sigl in 1870, and up to the time of its being exhibited it had been employed on passenger service. It has, as will be

seen from the perspective view on Plate CXI., outside cylinders, outside frames, and outside valve gear. It is, in fact, arranged on Hall's system the cranks are completely outside the axle bearings, the driving cranks having the eccentrics forged on them. The valve motion is of the shifting link type, and it gives motion to a "dummy" valve spindle working in guides, and provided with an arm which gives the motion to the valve spindle proper. The arrangement is thus similar to that employed in Mr. Sigl's express locomotive "Rittinger," which we have already described in detail.

The engine has two pairs of coupled wheels and an ordinary four-wheeled bogie at the leading end. The springs belonging to the coupled axles are independent, there being no compensating beams. The principal dimensions of the engine are as follows:

Cylinders:	ft.	in.
Diameter	1	4½
Stroke	2	0⅝
Distance apart from centre to centre	7	11¼
Wheels, &c.:		
Diameter of coupled wheels	5	2½
„ bogie „	3	1⅜
Distance between centres of coupled wheels	5	5⅜
Distance from centre of driving axle to centre of bogie pin	6	6¼
Distance between centres of bogie wheels	3	4½
Total wheel base	13	8¾
Distance from centre of trailing axle to outside trailing buffer beam	8	0⅞
Total length over frames	25	8½
Width of engine over all	9	8⅝

Boiler:	ft.	in.
Diameter of barrel	4	3⅝
Height of centre line above rail level	5	8½
Number of tubes	174	
Length of tubes between tube plates	14	1½
Diameter of tubes outside	.0	2·05
Heating Surface:		sq. ft.
Tubes, outside		1,315
Firebox		80·7
Total		1,395·7
Firegrate area		18·29 sq. ft.
Boiler pressure		125 lb. per sq. in.
		tons.
Weight of engine empty		32
„ „ in working order:		
On bogie wheels		12·25
„ driving wheels		12·0
„ trailing „		11·75
Total		36

The engine was shown at Vienna accompanied by its tender, and attached to a snow plough of the pattern used on the Nordwestbahn. The tender has six wheels, and is of a simple type, the tank extending the whole length and width, and the fuel space being on top. The tool box is arranged outside behind the tank. The principal dimensions are as follows:

	ft.	in.
Length over frames	18	4½
Width outside tank	7	6⅝
„ over all	8	5⅝
Height	8	8⅝
Diameter of wheels	3	2⅞
Distance between centres of of leading and middle wheels	5	4¼
Distance between centres of middle and trailing wheels	5	0½
Total wheel base	10	4⅜
Capacity of tank	1,870 gallons.	
„ fuel space	102¼ cubic ft.	

The engine and tender spoken of above, having been constructed and put to work in 1870, were exhibited as examples of the ordinary workmanship of their maker, and they were very creditable to Mr. Sigl. Our engraving on Plate CXI. has been prepared from a photograph of a sister engine to that exhibited, for which we are indebted to Mr. Sigl.

Close to the model station above alluded to was another similar pavilion forming an exhibit of the Kaiser Ferdinand's Nordbahn, this annexe containing three locomotives besides other examples of rolling stock and a variety of details of much interest of which we shall have to speak in due course. At present we have to treat of the locomotives only.

The Kaiser Ferdinand's Nordbahn, we may premise, is the oldest of the Austrian railways, and there are at present in use upon it 30 different types of locomotives, these types having been introduced at various dates between 1846 and the year 1873. Up to the year 1865 the goods trains were worked with four-coupled engines, but since that date the increase in the traffic has led to the adoption of a six-coupled type of greater power. In the earlier goods engines for this line the increased evaporative power of the boilers required for heavy loads was attempted to be gained principally by the provision of a large extent of tube surface, the firebox surface and grate

area appearing not to have been proportionally increased. The result was an accession of dead weight greater than the evaporative power of the boilers enabled to be effectively utilised; but in the more recent engines built since 1865, care has been taken to avoid this defect, while by providing large firegrate area and fireboxes, the inferior class of coal available has been economically burnt. These latter engines are also lighter per square foot of heating surface than those formerly built.

Between 1865 and 1870 there were constructed for the Kaiser Ferdinand's Nordbahn 77 six-coupled goods engines, in which the weight was limited to 10 tons per axle; during the last three years, however, the admissible weight has been increased to 12 tons per axle, and up to early in the year 1873 30 locomotives had been constructed in accordance with these new conditions, these engines being capable of taking trains of 500 tons up gradients of 1 in 150.

Goods Locomotive for the Kaiser Ferdinand's Nordbahn, by G. Sigl, Wiener-Neustadt.—Of the above-mentioned, now the standard type of goods locomotive for the Kaiser Ferdinand's Nordbahn, an example was exhibited at Vienna, the particular engine shown being the "Altvater," constructed by Mr. G. Sigl, at Wiener-Neustadt, in 1872. The general arrangement of this engine is shown by the diagrams, Figs. 1, 2, and 3, Plate CXVII., while the following are the principal dimensions.

	ft.	in.
Diameter of cylinders	1	5·1
Stroke	2	0·9
Diameter of wheels	3	11·4
Wheel base	10	7·6
Height of centre line of boiler above rail	5	7·3
Number of tubes	200	
Diameter of tubes outside	0	2·05
Length „ between tube plates	13	5·8
Length of engine over all	28	2½
Width „ „	10	0

Heating surface:	sqr. ft.
Firebox	100
Tubes (outside)	1445·4
Total	1545·4
Firegrate area	20·6
Pressure of steam 145 lb. per sq. in.	
	tons.
Weight of engine empty	32·25
„ in working order:	
On leading wheels	12·1
„ driving „	12·2
„ trailing „	11·8
Total	36·1

As will be seen from the diagrams the wheels are all arranged under the barrel of the boiler, while the cylinders and frames are outside, the cranks being fixed on the axles outside the bearings. The piston rods pass through the front cylinder covers. The valve gear is arranged inside, and is of the ordinary lifting link type. The springs are all arranged above the frames, and are independent, there being no compensating beams. The distribution of the weight is, as will be seen from the particulars above given, very good.

The barrel of the boiler is made of Bessemer steel, the upper plate of each ring being 11 millimetres (0·433 in.), and the lower plate 12 millimetres (0·472 in.) thick. The firebox is constructed with the top stayed direct to the crown of the firebox casing, the form being that introduced by Herr Ludwig Becker, the locomotive superintendent of the line. We have already alluded to this system of construction, and we shall hereafter speak of it more fully and describe it in detail. As will be seen from the particulars given above the firegrate area is to the total heating surface as 1 to 75·2, while the firebox surface is to the total heating surface as 1 to 15·45, or, in other words, it is equal to 6·45 per cent. of the latter. This is a much smaller percentage than is usual in the case of the goods locomotives now built in this country, but it compares favourably with the majority of the large continental goods locomotives, in which the firebox surface is frequently but one-seventeenth or one-eighteenth of the total surface. The tractive power of the engine under notice is $\frac{17 \cdot 1^2 \times 24 \cdot 9}{47 \cdot 4} = 153 \cdot 3$ lb. for each lb. of effective pressure per square inch on the pistons, so that an effective pressure equal to four-fifths of the boiler pressure, or 116 lb. per square inch, would give a tractive force of 17,782 lb. This, however, is a greater power than the adhesion weight would be capable of utilising, except under specially advantageous circumstances.

Of the normal type of engine used for working passenger traffic on the Kaiser Ferdinand's Nordbahn, no example was exhibited at Vienna, but it may nevertheless be of interest if we state briefly its principal characteristics. These engines, then, are six-wheeled, all the axles being, as in the case of the goods locomotives, arranged under the barrel of the boiler, the leading wheels being 3 ft. 11·4 in,, and the driving and trailing wheels, which are coupled, 5 ft. 3 in. in diameter. The cylinders are 15·55 in. in diameter, with 24·9 in. stroke, and are outside, as are also the frames. The valve gear is inside. The boiler shell is of Bessemer steel, the upper plates of the barrel being 10 millimetres (0·394 in.), and the lower plates 12 millimetres (0·472 in.) thick, while the side and top plates of the firebox casing are 12 millimetres and 16 millimetres (0·629 in.) thick respectively. The inside firebox is of copper. There are 164 tubes, 2·05 in. diameter outside, and 14 ft. 4 in. long between tube plates, these tubes giving an external surface of 1,253 square feet, and making, with 86 square feet of firebox surface, a total heating surface of 1,339 square feet. The firegrate area is 18·3 square feet. The weight of these engines is 26·85 tons empty, and 30·25 tons in working order, this latter weight being distributed as follows:—On leading wheels, 9·8 tons; on driving wheels, 11 tons; and on trailing wheels, 9·45 tons, The passenger engines are worked with a steam pressure of 120 zollpfunds per Austrian square inch, equal to 123 lb. per square inch English.

Six-coupled Tank Locomotive for the Kaiser Ferdinand's Nordbahn, by G. Sigl, Wiener-Neustadt.—Returning now to the engines exhibited in the pavilion of the Kaiser Ferdinand's Nordbahn, we have next to notice the six-coupled tank engine shown in outline by Fig. 4, Plate CXVII. This engine is intended for service on the Ostrau coal line, where it will have to haul trains up gradients of 1 in 50 in both directions. As will be seen from our illustration, the axles are all arranged under the barrel of the boiler, while the engine has outside cylinders, outside frames, and inside valve gear, the latter being of the Allan straight link type. This, we may remark, is the first engine on the Ferdinand's Nordbahn which has been fitted with the straight link gear, although this gear is extensively used on the continent. The springs are placed above the frames, and are independent of each other, there being no compensating beams. In addition to an ordinary brake worked by hand, the engine is fitted with a steam brake arranged as shown in our sketch, the brake being applied by admitting steam below a piston working in a vertical cylinder arranged between the driving and trailing axles as shown.

The barrel of the boiler is made of Bessemer steel plates from the Neuberg Works, the thickness being 12 mm. (0·472 in.). The firebox is constructed on Herr Becker's system, to which we have before alluded. The boiler is fed by a pair of injectors, and the water is carried in wing tanks, arranged as shown, while the coal bunkers are situated at the sides of the firebox, the arrangement being rather inconvenient, particularly on the right-hand side where the reversing gear is placed. The engine was built by Mr. G. Sigl, of Wiener-Neustadt, and its principal dimensions are as follows:

	ft.	in.
Diameter of cylinders	1	4·14
Stroke	2	0·9
Diameter of wheels	3	11·25
Height of centre line of boiler above rail	5	7
Number of tubes 132		
Diameter „ outside	0	2·05
Length „ between tube plates	12	9·5
Length of engine over buffers	28	3
Width „ „ all	9	10·9
Heating surface:		sq. ft.
Firebox		68·9
Tubes (outside)		908·4
Total		977·3

	sq. ft.
Firegrate area	16·14
Proportion of total heating surface to firegrate area 60·5 to 1.	
Pressure of steam 148 lb. per sq. in.	
	tons.
Weight of engine empty	29·25
„ „ in working order:	
On leading wheels	12
„ driving „	12
„ trailing „	12
Total	36

Shunting Engine for the Kaiser Ferdinand's Nordbahn.—The third locomotive, which was shown in the pavilion of the Kaiser Ferdinand's Nordbahn,

was a shunting engine rebuilt from one of the goods engines of the older class, and converted into a tank. The general arrangement of this engine is shown by Figs. 5, 6, and 7, Plate CXVII., while Figs. 8, 9, and 10 show details. The principal dimensions are as follows:

	ft.	in.
Diameter of cylinders	1	3·55
Stroke	1	10·3
Diameter of coupled wheels	4	1⅞
„ leading „	3	1·3
Length of wheel base	11	8
Diameter of boiler barrel	3	7
Number of tubes 107		
Diameter of tubes outside	0	2·05
„ „ between tube plates	9	2

Heating surface:	sqr. ft.
Firebox	66·8
Tubes (outside)	535·0
Total	601·8
Firegrate area	13·54
Pressure of steam	123 lb. per sq. in

In altering the older goods engines of the Ferdinand's Nordbahn into shunting engines there were many difficulties to be overcome, as the former belonged to a very old type of locomotive, while it was of course desirable to use as many of the existing parts as possible. However, the reconstruction has been successfully accomplished, and the engines produced have been found to perform their required services very satisfactorily. The alteration and conversion into tanks has added about five tons to the weight of the engines.

As will be seen from Figs. 5, 6, and 7, Plate CXVII., the engine under notice has outside cylinders, and inside frames and valve gear, the latter being of the Stephenson type. The leading and driving axles are arranged under the barrel of the boiler, while the trailing axle is behind the firebox; the driving and trailing wheels are coupled. The engine is carried entirely upon volute springs, arranged in groups of three, as shown. As will be seen from the dimensions given above, the cylinder power is large in proportion to the heating surface, a good point in a shunting engine, which has frequently to exert a great effort for a short period. Although, however, the total heating surface is very moderate, it will be noticed that, as the tubes are short, a large proportion of it is firebox surface, the ratio between the tube and firebox surfaces being 8 to 1 only. The firegrate area is also large, the ratio between this area and the total heating surface being 1:44·46.

The barrel of the boiler is made of Bessemer steel plates 9 mm. (0·354 in.) thick, while the firebox, which is of copper, is made with a semicircular top, as shown in Figs. 8 and 9, Plate CXVII. It will be seen from these figures that the firebox crown in this case is not corrugated according to the system introduced by Mr. Haswell, but is made perfectly plain and without any stays whatever. The thickness of the plate forming the sides and crown is $\frac{5}{8}$ in.

The principal supply of water is carried in a saddle tank, but there is also a smaller tank arranged below the footplate. The coal boxes are arranged in the corners at the back of the footplate, as shown in the plan Fig. 7. The arrangement of the engine allows of a brake being applied to the wheels on one side only, and this is constructed as shown by Fig. 10, the cast-iron blocks being forced against the wheels by the action of a pair of toggle levers, actuated by a brake screw and hand wheel. The particular engine exhibited was rebuilt at the works of the company in 1871, and there can be no doubt that it is of a class which will do its work well.

The remaining figures 11 to 16 on Plate CXVII. show one of the boilers for goods engines as now built on the Kaiser Ferdinand's Nordbahn. This boiler we shall describe hereafter when treating of locomotive engine details.

Passenger Locomotive, by the Wiener Locomotiv Fabriks Gesellschaft.—Returning now to the Austrian section of the Machinery Hall we have next to speak of the bogie passenger locomotive "Rafael Donner" constructed by the Wiener Locomotiv Fabriks Actien Gesellschaft (Bernhard Demmer, Director) of Floridsdorf, near Vienna, which forms the subject of Plates CXVIII. and CXIX. In many respects this engine resembles the "Rittinger," Mr. Sigl's express passenger locomotive for the Southern Railway of Austria, already described, but the engine now under notice has a greater extent of heating surface and smaller wheels than the "Rittinger," being intended for doing heavier work at lower speeds. In these respects it in fact more closely

resembles Mr. Sigl's engine exhibited in the pavilion of the North-western Railway of Austria, and illustrated on Plate CXI.

Referring to Plates CXVIII. and CXIX., it will be seen that the engine now under notice, has outside cylinders, outside frames, and outside valve gear, the latter, which is of the shifting link type, being arranged between the frames and the cylinder motion, the eccentrics being forged solid with the bosses of the driving cranks. The valve chests are on the tops of the cylinders, and as is usual where this arrangement of gear is adopted, the latter gives motion to a "dummy" valve spindle, an arm on which drives the valve spindle proper. The general design of the motion will be seen from the engravings, and it will be noticed that the expansion links and eccentric rods are balanced by a counterweight fixed on the link which connects the reversing arm on the weigh bar with a corresponding arm on a short reversing shaft above the level of the frame.

The frames are each made of two plates with distance pieces between them, and they are well connected by transverse stays, the connexion at the leading end being more substantial than in many engines of a similar type, of which we have had occasion to speak. The connexion between the firebox casing and the frames is effected by stays constructed so as to provide free expansion of the boiler to take place, this expansion being allowed for by the lateral deflection of the plates which form the stays. These stays are shown in detail by Figs. 4, 5, and 6, Plate CXIX. All the axles are arranged under the barrel of the boiler, but the fact of the engine having outside frames enables the trailing axle to be kept very close to the firebox casing, so that the overhang at the firebox end is not so great as to be objectionable. The springs, it may be added, are all independent, there being no compensating beams.

The springs are made with a form of end used on a number of the engines exhibited, and shown by the sketch, Fig. 10, Plate CXIX. In this case the knife edge bearing for the washer under the nuts on the spring links, instead of being forged on the top plate of the spring, or formed by turning back the latter, is formed on a loose piece of plate which is bent down over the end of the spring, as shown. Probably this is the best way of forming the knife-edge bearings when the latter are used. We may remark here that on the engine under notice, as well as on many others exhibited, the check nuts on the spring links were wrongly arranged, the thin nuts being placed at the top. This is a common mistake made by engineers, and one which ought to be exposed. A little reflection only is required to show that a pair of nuts are only really locked when the pressure of the one on the other forces them to take bearings on the opposite sides of the screw threads, and when this is the case the inner nut, or that which is made the thicker of the two in ordinary practice, is really in such a position with regard to the screw threads that the whole strain due to the pressure which the nuts have to withstand is thrown upon the outer or check nut. The correct plan is, as we have said, to make the outer nut the thicker one; but when there is any doubt about workmen putting on the nuts properly, it is perhaps best to make the latter of equal thickness. We noticed that some of the locomotive builders who exhibited at Vienna adopted this latter practice.

The distribution of weight in the "Rafael Donner" is, as will be seen from the particulars given hereafter, very good. The bogie is of an ordinary type, and has a spherical centre carried by a bracket on the boiler.

The boiler has the top of the firebox casing made flat, and stayed to the firebox crown on Herr Becker's system, as shown in the side and back elevations. A manhole is provided in the barrel just in front of the firebox casing, while at the front end there is a very large dome, as is usual on Austrian engines. The regulator is fixed outside the dome, external steam pipes leading from it to the cylinders, as shown. The exhaust is variable, and the smokebox is fitted with an inclined screen or spark arrester, extending across it just above the level of the tubes. A pipe and cock are also provided for discharging water into the smokebox just above this screen, this water pipe being led off from the left-hand delivery clackbox. The chimney is of cast iron. The boiler is fed by a pair of injectors with fixed nozzles, arranged below the footplates.

The engine is provided with sandboxes having the valves worked from the footplates, and all the general fittings are very conveniently arranged. Our engravings are fully figured with metrical dimensions; but, for convenience of comparison, we subjoin the following table of the principal dimensions in English measures.

Cylinders:	ft.	in.
Diameter	1	4½
Stroke	2	0⅝
Distance apart from centre to centre	7	11¼
Wheels, &c.:		
Diameter of coupled wheels	5	2½
„ bogie wheels	3	1⅜
Distance between centres of bogie axles	3	4½
Distance from centre of bogie pin to centre of driving axle	6	6¾
Distance between centres of coupled wheel	5	5⅜
Total wheel base	13	8¾
Boiler:		
Diameter of barrel inside largest plate	4	3⅜
Length of firebox inside at top	4	9⅜
Length of firebox inside at bottom	5	0
Width of firebox inside at top	3	8⅜
Width of firebox inside at bottom	3	7¾
Height of firebox inside at front	4	8⅜

Boiler—cont.	ft.	in.
Height of firebox inside at back	4	2⅞
Number of tubes 172		
Diameter of tubes outside	0	2·05
Length of tubes between tube plates	14	1½
Heating surface:	sq. ft.	
Firebox	91	
Tubes (outside)	1,299	
Total	1,390	
Firegrate area	18·3	
Pressure of steam	147 lb. per sq. in.	
	tons.	
Weight of engine empty	33·75	
„ „ in working order:		
Weight of engine on bogie	12·3	
„ „ driving wheels	12·3	
„ „ trailing „	12·3	
Total	36·9	

Goods Locomotive, for the Hungarian State Railways, constructed at the works of the Company.—Hungary was represented at the late Vienna Exhibition by one locomotive only, namely, that forming the subject of Plate CXX. and Figs. 4 and 5 on Plate CXXI. The locomotive is one intended for goods service on the Hungarian State Railways, and it is, as will be seen, a six-coupled engine arranged on the Hall system with outside cylinders, outside frames, and inside valve gear. It was constructed at the works of the Hungarian State Railways at Pesth — works of which Mr. F. Zimmermann is the director.

The general arrangement of the engine and the chief details of its construction are so clearly shown in the engravings, that but a very brief description will be necessary. As is almost invariably the case with the Continental goods engines, the axles are all situated under the barrel of the boiler, so as to get a short wheel base, while to facilitate the passage of curves a small amount of lateral play is allowed to the trailing axle. The wheels, it will be noticed, have cast-iron bosses. The axle boxes and guides are without adjusting wedges, and the driving and trailing springs are connected by compensating beams. The axle bearings are formed on the bosses of the cranks, as shown in the plan. The diameter of the wheels is 3 ft. 11¼ in., and the wheel base 10 ft. 4½ in., the axles being placed equal distances apart.

The frames are each composed of two plates with distance pieces between them, and they are firmly connected by transverse stays, except that at the leading end there is that want of efficient means of insuring "squareness" of the engine which we have had occasion to allude to on previous occasions as distinguishing so many continental—and particularly Austrian—locomotives. The cylinders, which are 18⅛ in. in diameter, with 24⅞ in. stroke, are, in the engine we are describing, well fixed to the frames, and the two valve chests, are as in some engines of which we have already given an account, connected at the bottom by a heavy wrought-iron plate bolted to them. The slide valves are of the Haswell pattern, and the link motion is of the Stephenson type, its principal dimensions being given by the diagram, Fig. 4, Plate CXXI. It will be noticed that the fore-gear eccentric rod is coupled to the bottom of the link, instead of to the top, as usual. A somewhat complicated form of valve rod also is employed to transfer the motion past the leading axle (see longitudinal section, transverse section, and plan).

The engine has a total heating surface of 1,379 square feet, a grate area of 17·6 square feet, and weighs, in working order, 36 tons.

Russia.

Russia was represented at Vienna by two locomotives, one for passenger and one for goods service, both these engines being very creditable specimens of workmanship. To what extent this workmanship was purely Russian it is of course impossible for us to say, but taking them as they stood they were as we have stated decidedly creditable. We shall describe them in the order in which we have mentioned them.

Passenger Locomotive constructed at the Kolomna Engine Works.—This engine, which we illustrate by Figs. 1, 2, and 3 on Plate CXXI., was built at the Kolomna Engine Works, and is the 100th locomotive turned out at that establishment. As will be seen it is of an English type, with outside cylinders and inside frames and valve motion. The cylinders are 16 in. in diameter, with 22 in. stroke, and the coupled wheels 5 ft. 3 in. in diameter. The gauge for which the engine is built is of course 5 ft. The boiler contains 182 tubes $1\frac{7}{8}$ in. diameter outside, and 9 ft. $10\frac{3}{8}$ in. long between tube plates, these tubes giving an external surface of 882 square feet, and making, with 80 square feet of firebox surface, a total heating surface of 962 square feet. The grate area is $16\frac{1}{2}$ square feet, and the steam pressure 10 atmospheres effective, or 147 lb. per square inch. The boiler plates are very thick, the barrel plates being $\frac{9}{16}$ in., and the firebox shell plates no less than $\frac{3}{4}$ in.

The valve gear is of the Allan straight link type, and is reversed by a screw. The slide valves are of the Haswell or Trick pattern, giving double openings for admission. The engine is carried on five springs, the leading and driving springs being connected by compensating beams with unequal arms, and there being a transverse trailing spring, so that the engine is practically supported on three points. The springs are all made of $3\frac{1}{2}$ in. by $\frac{1}{2}$ in. plates, and leading, driving, and trailing springs consist of 11, 8, and 23 of these plates respectively. The leading and driving springs have a span of 3 ft., and the trailing spring one of 4 ft. 2 in. The weight of the engine is $28\frac{1}{2}$ tons empty, and $32\frac{1}{2}$ tons in working order, this latter weight being distributed as follows: on leading wheels $11\frac{1}{2}$ tons, on driving wheels 10 tons, and on trailing wheels 11 tons. The general details and the principal dimensions being given in our engravings, we need merely repeat here that the workmanship of the engine exhibited was most creditable.

Goods Locomotive for the Great Russian Railway Company, constructed at the St. Petersburg shops of the St. Petersburg and Warsaw Railway.—As will be seen from Plates CXXII. and CXXIII., this engine, which is for the 5 ft. gauge, has outside cylinders, and inside frames, and valve gear, while the general details of its construction are so clearly shown that but a brief description of it will be necessary.

The boiler has a flush-topped firebox casing, and is provided with a copper firebox and brass tubes, the only noticeable point in its construction being that the lower part of the back plate of the firebox casing is inclined outwards, so as to enable an increased grate area to be obtained. The sides and crown of the casing, it will be noticed (see transverse section), are made up of no less than five plates. The engine is intended for burning wood, and the chimney is provided with a spark-arresting arrangement, as shown in the transverse section through the smokebox on Plate CXXIII. The form of the hind dome is somewhat peculiar, and it will be noticed that the front dome, which contains the regulator, is provided with a steam collecting pipe, which extends from it along the top of the boiler, and which is slotted at intervals along its upper side. The firebars can be dropped by means of a lever and screw, as shown.

The framing is of a type much used in England some 20 years ago, each frame consisting of a straight plate of uniform depth (except at the ends where its depth is increased) having the horpplates bolted to it on each side. This mode of construction appears to us to be a backward step in locomotive engine building, and the frame is altogether lighter than we should deem it advisable to employ on such an engine. At the leading end the frames are connected by a plate forming a kind of double bottom to the

smokebox (see transverse section on Plate CXXIII.), while the cylinders are further connected by a rectangular transverse frame bolted to flanges formed at the bottoms of the valve chests as shown. The axle-box guides are of wrought iron, and are fitted with wrought-iron wedges, whilst the axle boxes themselves are also of wrought iron. The springs are all arranged above the frames, and those for the driving and trailing axles are connected by compensating beams.

The valve gear is of the shifting link type, and the valve spindles proper are driven from arms formed on "dummy" spindles, this arrangement being adopted to increase the distance between the centres of valve spindles, and to thus enable short ports to be obtained. The crossheads, connecting rods, and coupling rods are of neat patterns and good proportions. The pistons are of wrought-iron, and are fitted with cast-iron rings. The reversing lever, as will be seen from the side elevation, Fig. 1, Plate CXXIII., is very short, and has a most unusually—and we consider inconveniently—large angular range.

The boiler is fed by a pair of injectors with fixed nozzles, arranged below the footplate, as shown. The sand-box is fitted with valves worked from the footplate, and the latter is protected by a spacious cab. The engine was accompanied at the Exhibition by a six-wheeled tender, of which we give outline views in Figs. 4 and 5, Plate CXXIII., and this tender, together with the engine, were fitted with the Heberlien brake. This brake is not shown on the general views but we shall be able to explain its arrangements by reference to the outline sketches, Figs. 6 and 7, Plate CXXI. The tender brake proper we may premise is of an ordinary type, with cast-iron brake blocks ; but in addition to the usual screw for applying this brake there is also provided an arrangement by which the tender brake, and also brakes fitted to the driving and trailing wheels of the engine, can be applied by pulling a chain which extends back to the train. The manner in which the pressure is applied to the engine brake blocks is rather peculiar, and to explain it we refer to the diagram, Fig. 6, Plate CXXI. This diagram shows a plan of the gear by which the brake blocks are forced against the driving and trailing tyres D and T. In this gear *a a* are a pair of levers turning on pins *d d* formed at the lower ends of the trailing brake block hangers, and connected by the adjusting screws *c* with the crossbar *b*. The brake hangers on which the pins *d d* are formed carry at a higher level the cast-iron brake blocks *e e*, shown by dotted lines, while the crossbar *b* is slung from the brake hangers carrying the blocks *f f* applied to the driving wheels. The two levers *a a* are of such length that they lap over each other at the middle of the engine, and they there pass through the forked end of the rod *g*. To this forked end is fitted the friction roller *h*, and it is evident that by pulling on the rod *g* the roller is forced against the levers *a a*, and the latter turning on the pins of the adjusting screws *c c* as fulcra, force the blocks *e e* against the trailing wheels, and at the same time by pressing against the bar *b* apply the brake to the driving wheels. On the other hand, when the pull on the rod *g* is relaxed the spring *i* attached to the bar *b* acts through the connecting links *k k* and draws the levers *a a* and the crossbar *b* together, thus taking off the brake.

We have now to explain how the necessary pull is applied to the rod *g*. This is explained by the diagram, Fig. 7, Plate CXXI., which is a skeleton view of the arrangement fitted to the tender. In this diagram A is the leading axle of the tender fitted with a friction wheel B. Another similar friction wheel C is carried at the lower end of the vertical arm of a pair of bell cranks D D, these bell cranks being sufficiently wide apart to carry the friction wheel between them. The bell cranks turn on a fixed centre at E, and they carry a counterweight F, while by means of the rod G the horizontal arm of the bell crank is kept raised, and the friction wheel C is thus held clear of the wheel B. By pulling a chain which extends from the tender to the train the detent which holds up the rod G can be released, and the weighted arm of the bell crank D then falls, thus bringing the friction wheels into contact. As the wheel C is thus made to revolve in the direction of the arrow (the engine being supposed to be running forwards) there are wound on its axis a pair of chains H, these chains passing one

along each side of the friction wheels, and being led over the pulley I at the lower end of the lever K, which turns on a fixed point L. From this pulley the chains, united into one, are led forward to the engine and attached to the rod *g*, Fig. 6, of which we have already spoken. It will thus be seen that the effect of bringing the friction wheels into contact is to haul in the chain H, put a tensile strain on the rod *g*, and thus apply the brakes to the driving and trailing wheels of the engine. But the lever K is also coupled at M to the thrust rod N, which extends to a lever O on the brake shaft P of the tender, and thus at the same time as the chain H is wound up the shaft P is partially turned and the tender brake applied. It will be noticed that the pull upon the chain H tends to draw the friction wheels harder together, and it appears to us that with the means available the brake must be one which is difficult to release promptly, while it is undoubtedly complicated.

The principal dimensions of the engine we have been describing are as follows :

	ft.	in.
Cylinders:		
Diameter of cylinders -	1	5·32
Stroke - - - -	2	0·4
Distance apart from centre to centre - - - -	7	0·8
Wheels:		
Diameter - - - -	4	3·2
Distance between centres of leading and driving - -	6	1½
Distance between centres of driving and trailing - -	4	11
Total wheel base - -	11	0½
Boiler:		
Diameter of barrel inside largest plate - - -	4	3·2
Length of firebox casing at bottom - - - -	5	5½
Length of firebox inside at bottom	4	11
Width „ „ „	3	2½

	ft.	in.
Boiler—cont.		
Height of crown above grate -	5	2
Number of tubes - - 162		
Diameter „ outside -	0	1·97
„ „ inside -	0	1·81
Length of tubes between tube plates - - -	13	10½
Heating surface:	sq. ft.	
Firebox - - - -	90·4	
Tubes, outside - -	1,158·2	
„ inside - -	1,065·8	
Total, with external tube surface - - -	1,248·6	
Total, with internal tube surface - - -	1,156·2	
Firegrate area - - -	16	
Pressure of steam -	125 lb. per sq. in.	
	tons.	
Weight of engine empty - -	28½	
„ „ in working -	31½	

Miscellaneous Details.

We have now described at greater or less length the whole of the locomotives exhibited at Vienna; but there remain several examples of details, shown apart from complete engines, which are worthy of notice, and respecting which, therefore, we must say a few words here.

Thus we may instance in the first place the form of injector designed by Mr. F. W. Webb, the locomotive superintendent of the London and North-Western Railway, shown at Vienna by Messrs. Sharp, Stewart, & Co. Limited. We give on Plate CXXIV. detail views of this injector, and also views showing the mode of fixing it adopted by Mr. Webb. Referring to the former figures (which are two vertical sections taken at right angles to each other), *a* is the water supply pipe, and *b* a part of the injector having the lateral passage or branch b^1, to which the steam supply pipe b^2 is connected, as shown. The steam nozzle b^3 is screwed into the end of the lateral passage. The body part *c* of the injector is made in one piece, and is bored out to fit the combining cone or nozzle and the discharging cone or nozzle, and it has a slot formed in it large enough to admit the overflow chamber and allow of its movement for adjustment. The combining and discharging nozzles *d* and *e* are made in one piece, and they are made to pass through the two sides of the overflow chamber *f*, and are ground to fit tight, and secured by a screw nut e^1 having notches in its edge, so that it can be rotated by a suitable screw key.

The combining and discharging nozzles *d* and *e* (especially the latter) are made to fit as accurately as possible in the bores of the body of the injector, and there are lateral passages d^1 to allow the fluid to escape into the overflow chamber when required. This chamber *f* has a hollow cone plug f^1 fitted in it, secured by a screw nut f^2 and washer f^3, as shown, the waste fluid escaping through the hollow of the plug when the cock is opened, and may be conveyed in any convenient direction by a pipe screwed into the plug. To one end of the plug of the cock one end of a shaft *g* is connected, while the other

end is screwed and passes through a corresponding nut in a hand wheel g^1, having bearings on the clack-box, as shown. The cock is opened or shut by turning the lever handle on the shaft *g*.

The injector, clack-box, and stop valve are shown combined in our engravings, *h* being the ball valve or clack, and *i* the stop valve, which is secured to the boiler by bolts, as shown, the injector part being further secured by bolts passing through the bracket cast upon the body part of the injector. It will be seen that in the arrangement we have described the injector forms a direct continuation of the pipe communicating between the water supply and the boiler, while when the cock of the overflow chamber is closed the steam may be made to pass back from the injector to the water supply to warm the feed water, thus dispensing with special pipes for this purpose.

It will be noticed on reference to the figures that the lower end of the injector is steadied by a kind of forked bracket, which bears against the firebox casing, and is held by a couple of studs. By simply slacking the nuts on these studs, closing the stop valve, and breaking the cone joint beneath the clack and the joint with steam pipe, the injector can be at once slipped down and examined or exchanged while the engine is under steam. In fact the whole arrangement is thoroughly simple and workmanlike.

The manner in which these injectors are fixed by Mr. Webb is as we have said shown by two other views on Plate CXXIV., these views also showing the arrangement of Mr. Webb's boiler mountings generally. Every one who has had charge of running engines well knows that feed-pipes are a source of trouble, and although this trouble is much less now-a-days, when injectors are almost universally used, than it was in former times when pumps were employed, yet still feed-pipes put in appearances on the repair list too frequently to be regarded as unobjectionable details.

Referring to our illustration it will be seen that Mr. Webb has got over this trouble by practically abolishing feed-pipes altogether. Placing the injectors at the back of the firebox casing with the delivery ends uppermost, he conducts the water direct from them through short straight brass pipes to the delivery clack boxes, which are fixed to the back of the firebox near the water level. The feed, however, is not delivered at that point, but is led along an inside pipe which extends from each clack to about the middle of the barrel of the boiler. These inside pipes being exposed to no pressure can be formed of old boiler tubes.

As will be seen from our engraving, the various details of the arrangement have been ably worked out, and altogether this mode of fixing injectors, which we should mention has been patented by Mr. Webb, effects an important saving of cost, and is well worthy of adoption. It will be noticed that the delivery pipe of one injector is fitted with a branch for the attachment of a fire hose. By this arrangement, which has for some years been in use on some of the Russian railways, a locomotive can be at once turned to account as a fire engine in the event of a fire breaking out at a station. The injector is of course far from being an economical apparatus for forcing water for fire-extinguishing purposes; but in cases of emergency this is a secondary matter, and the simple provision we have mentioned enables a locomotive to do good service when a regular fire engine is not available.

Besides the injectors there is another point about the arrangement we illustrate which is worthy of notice, and that is the mode of fixing the whistles and injector steam cocks. Instead of attaching these fittings separately to the boiler, they are all mounted on a gun-metal standard, fixed on the top of the firebox casing, as shown, there being thus but one joint made with the boiler. The standard, together with the steam cocks, is inclosed in a sheet-iron casing, as shown, so that it is unnecessary for it to be got up polished. The whole arrangement, besides possessing practical advantages, has a very neat and symmetrical appearance. It is much to be regretted that one of Mr. Webb's boilers, with all its fittings, was not exhibited at Vienna.

Another detail designed by Mr. Webb and made by Messrs. Whitley Partners, of Leeds, who were exhibitors of a large variety of engine fittings at Vienna, is the arrangement of gauge glass fittings, also illustrated on

Plate CXXIV., the leading features in these fittings being their simplicity of construction. Referring to the figures it will be seen that the valves occupy positions in front of the fixings for the glass tube, the steam and water being brought to them through lateral passages, as shown at *e e*, Fig. 2. Each valve consists of two reversed conical faces formed upon the end of a screw, the arrangement being such that when screwed in one way the valves close the passages to the end of the glass gauge tube, and at the same time allow of a small escape of steam along the screwed spindle (no packing being used), this escape serving to indicate the fact of the gauge not being in working order. When screwed in the other direction the valves assume what may be regarded as their normal positions, the passages to the glass tube being open, and the conical faces at the backs of the valves bearing against suitable facings and preventing leakage along the screwed spindles. The spindles *f* have dished heads *f* fixed to their ends, as shown, these heads preventing any steam which may escape from being blown directly outwards.

At the bottom of the lower fitting there is a blow through valve *g*, constructed in the same manner as above described, but arranged so that its normal position is that in which it is shown in the figure, the escape of steam along its screwed spindle only taking place when it is left open. To the top of the upper fixing *b* is fitted a cup and cone winch *c*, for attaching the pipe leading to the pressure gauge. By removing this cup and pipe the gauge glass can be replaced when necessary in the usual way. The details of this set of gauge glass fittings are very well worked out, and the whole arrangement is so simple as to well merit attention.

In the German section Mr. Peter Scharuberger, of Nuremberg, showed some of his lubricators, of which we give a sketch on Plate CXXV. In this lubricator the quantity of lubricating material supplied to the cylinder to which the contrivance is fitted, is regulated by turning the spindle *c*, which terminates in a conical screw, as shown. The receptacle is filled through the valve *a*.

As we have had occasion to mention in describing the various locomotives, "non-sucking" injectors, or injectors with fixed nozzles, are very largely used by the continental locomotive builders. Amongst the injectors thus used are Friedmann's, which is well known here, and Schau's, the latter being a very simple type, of which we give views on Plate CXXV., views which will show the construction clearly, without requiring any special explanation.

In the Austrian section of the Machinery Hall was exhibited a somewhat novel arrangement of stuffing box, which has been largely applied to locomotives on the Austrian State Railways, and which has given results sufficiently satisfactory to render it worthy of special attention. The arrangement, which is illustrated on Plate CXXIV., is one designed by Mr. P. Massing, of Vienna, and its leading features are that, in the first place, the stuffing box is entirely independent of the cylinder, and, in the second, that the lubrication of the packing is effected by water, instead of oil, the special object in view being to prevent, as far as possible, injury from being done to packing by the elevated temperature of the high pressure steam.

Referring to the engravings, it will be seen that the cylinder cover is without the usual stuffing box, and is merely fitted with a brass bush *c*, the external collar of this bush really forming the gland. The stuffing box itself *g g* is of brass, and slides freely on the piston rod, being capable of being tightened up against the bush *c* by means of studs and nuts, as usual. The packing used consists of a ring formed of rather closely twisted hemp, this ring—which is shown separately on the right-hand side of our engraving—being of a conical form externally, and fitting into a correspondingly shaped cavity *b* in the stuffing box. Of course when the box is forced home by the nuts the packing ring is compressed by coming into contact with the collar of the bush *c*.

The stuffing box is, as will be seen, cylindrical and hollow, so that it affords considerable space *a a* for holding water, while a number of small holes *f f f* give this water access to the packing. At *h* is a hole for filling the box, whilst *i* is an air hole, and *b* a plug for drawing off the water if necessary. At *e* is a small hole for applying oil lubrication if required.

On the Austrian State Railways an engine fitted with the arrangement above described, and using steam at a pressure of nine atmospheres effective, or, say, 132 lbs. per square inch, has run over 9,200 miles without having the packing renewed, and altogether the results obtained have, as we have said, been so satisfactory that this water stuffing-box is now being extensively used on that line. The whole arrangement is very simple, and it appears to us well worthy of a trial here in cases where, from the use of very high pressure steam, trouble is being experienced with burnt packing.

By far the largest and most interesting collection of locomotive details exhibited at Vienna, however, was that contained in the special pavilion of the Kaiser Ferdinand's Nordbahn, a pavilion to which we have already alluded as being built near the eastern end of the Machinery Hall. Of these exhibits, many of which are illustrated on Plates CXVII., CXXIV., and CXXV., we have now to speak.

First in order we may take the example which was shown of the standard types of piston, piston rod, crosshead, and guide bars, these parts being exhibited fitted up together, as shown on Plate CXXV. The experience on the Kaiser Ferdinand's Nordbahn is to the effect that in wrought-iron pistons the grooves for the rings wear too rapidly, and the locomotive superintendent of the line, Herr Ludwig Becker, has, therefore, for some time past used hollow cast-iron pistons, cast in one piece, as shown; these pistons being, of course, much cheaper than those of wrought iron, and proving also more durable. The piston exhibited is for a $15\frac{5}{8}$ in. cylinder, and it is $4\frac{5}{8}$ in. thick, and has two cast-iron rings recessed into it, as shown. These rings are each 1·45 in. by 0·51 in., and they are of uniform section all round, and are half-lapped at the joints, a small set pin screwed into the piston, as shown, serving to maintain the two rings in their proper relative positions.

The piston rod is enlarged at both the piston and crosshead ends, as shown, thus necessitating that the packing ring and bush of the gland should be made in halves. The piston rod is very slightly tapered where it enters the piston, and it is secured in place by rivetting over the end. Upwards of 400 piston rods thus fitted are now in use on the Kaiser Ferdinand's Nordbahn, and not a single instance of a rod so fixed coming loose has occurred.

The crosshead is of wrought iron and is a pressed forging. The slide bars are 92 millimetres, or $3\frac{5}{8}$ in. wide, and the wearing surfaces of the crosshead are $15\frac{1}{2}$ in. long. The arrangement of oil box for lubricating the small end bearing of the connecting rod, and the mode of securing the crosshead pin are clearly shown in our engravings.

The next detail we have to notice here is the mode adopted on the Kaiser Ferdinand's Nordbahn of securing the keys for the eccentrics. The plan adopted is shown on Plate CXXIV. From the last-mentioned figure it will be seen that the keyway in the driving axle is undercut at the ends so as to form a kind of dovetail. The key itself is correspondingly shaped, and is bent to enable it to be put in, as clearly shown by Fig. 3. It will be seen also from Figs. 2 and 3, that this key is notched down at the middle of its length, the keyway in the eccentric fitting this notch, and the sheave being thus prevented from shifting sideways. This mode of fixing eccentric keys has now been in use for a number of years by the Kaiser Ferdinand's Nordbahn.

The self-acting lubricators shown on Plate CXXIV. are two designed and patented by Mr. August Anschülz, one of the engineers of the Kaiser Ferdinand's Nordbahn, and examples of them were exhibited in the pavilion to which we have already so frequently referred. The lubricator shown by Figs. 1 and 2, on Plate CXXIV., is especially intended for supplying oil to cylinders and slide valves, its arrangement being such that this supply is only furnished when the engine is running. As will be seen from the views, the oil is, by means of a wick, fed from the outer receptacle, or oil cup proper, into a secondary or inner receptacle, this latter communicating, by means of two very small tubes, with a chamber, which may be considered as forming part of the leg of a $\mathfrak{h}$-shaped passage. In this passage there are two valves, both opening towards the cylinder or valve chest to be lubricated, the inner or smaller valve, however, opening downwards. This valve, therefore, falls

open when the pressure of the steam ceases to act against the underside. The effect of this arrangement is to cause the passage between the two valves to be alternately filled with oil and discharged into the cylinders or valve-chests. The lubricator just described is fitted to all the locomotives on the Kaiser Ferdinand's Nordbahn, and it is also employed on other lines. Altogether some 6,500 of these lubricators are in use.

The other lubricator, shown by Mr. August Anschülz, is that represented by Fig. 3, of the group of views on Plate CXXIV. In this case the passage in the stem of the lubricator communicates at the top with a horizontal hole, the effective area of which is regulated by an adjusting screw, as shown. This horizontal passage is in its turn intersected by a hole, in which a small piston or plunger works. This piston is attached to the free end of a Bourdon tube, the other end of which is in communication with the main passage in the stem, as shown in the plan. The interior of the Bourdon tube is thus filled with steam, and the variations of the density of the steam in the cylinder or valve chest to which the lubricator is attached are thus repeated in the tube. This causes the tube to expand and contract, thus making the piston just mentioned reciprocate in its bore, and as this takes place in a reservoir filled with lubricating material, some of this is carried forward by the plunger and delivered to the opening communicating with the main channel in the stem of the lubricator.

In the foregoing pages we have frequently had occasion to point out the almost exclusive use, by Continental engineers, of injectors with fixed nozzles. With these injectors it is desirable that in starting the steam should at first be turned on gradually and then put on full, and to meet these requirements, the valve, of which we give an illustration on Plate CXXV., has been designed by Mr. Rayl, one of the chief engineers of the Kaiser Ferdinand's Nordbahn. The construction of this valve will be readily understood. From the engravings it will be seen that the valve is of the mushroom form, opening inwards, and fitted at its centre with a small auxiliary valve, which covers four very small oblique holes, drilled to its face from the upper side of the main valve. This secondary valve is really formed on the spindle by which the main valve is opened, this spindle being allowed to slide through the main valve for a limited distance controlled by the check nut shown.

On pressing down the lever, to which the spindle just mentioned is coupled, the small auxiliary valve is first opened, and subsequently the larger valve, a kind of trigger fitted to the guide by which the lever is steadied serving to hold down the lever, and thus keep open the valve as long as may be required. This arrangement of valve, which is now in very extensive use, is very neat and efficient, and we may say that the workmanship of the example exhibited, as well as a variety of other brasswork included in the collection, was most excellent.

We also illustrate on Plate CXXV. the standard form of head and tail lamps in use on the Kaiser Ferdinand's railway. These lamps, which are adapted for burning petroleum oils, have been in use on the above-mentioned line since 1866, and the results obtained with them both as regards light-giving power and economy have been most satisfactory. The light is equal to nine candles. The lamps have, as will be seen, argand burners, and the general construction will be at once understood from the engravings.

Continuing our survey of the examples of details of locomotive construction contained in the pavilion of the Kaiser Ferdinand's Nordbahn, we have next to speak of two examples of boiler making exhibited, the one being a boiler for a re-constructed goods engine and the other a firebox of an exactly similar boiler shown after being in use from August 1870 to April 1873, during which period the engine to which it belonged had run 72,953 kilometres, or about 45,300 miles. In this latter case the boiler had been cut through, tubes and all, a few inches from the firebox tube-plate, and it was shown in the exact condition in which it was found after the above-mentioned service. The result showed the firebox to be in very good condition, the roof stays being quite tight and in perfect order. The new boiler, also, was shown with the firebox detached from the barrel, so that the construction could be fully examined. The boiler shell is like all constructed at the shops of the company since 1865, made of Bessemer steel plates, the barrel consisting of

two plates only, connected by a butt joint with external covering strip. The longitudinal joints are lap joints; the joints of the two plates being placed in line as shown, instead of being arranged to break joint as would have been preferable. Both longitudinal transverse joints are double rivetted.

The engravings of this boiler, on Plate CXVII., Figs. 11 to 16, include general views, and also enlarged longitudinal and transverse sections of the firebox. From these figures it will be seen that the chief structural peculiarity of the boiler consists in the mode of staying the firebox crown, this staying being effected on the system of Herr Ludwig Becker, the locomotive superintendent of the Kaiser Ferdinand's Nordbahn—a system of which we have frequently had occasion to speak in the course of this report.

And here it is only just that we should state that the first suggestion that the crowns of the firebox and casing should be stayed directly together in the same manner as the side, is undoubtedly due to Mr. Thomas R. Crampton, who as long ago as 1849 took out a patent for improvements in locomotive construction, in which this arrangement was included. The system of staying firebox crowns thus originated has since been developed in various ways by different locomotive engineers. In Belgium, M. Belpaire has employed largely the firebox known by his name, the firebox casing being made with a flat crown considerably raised above the barrel of the boiler, this flat crown being directly stayed to the top of the firebox, while longitudinal and transverse stays strengthen the flat ends and sides of the casing. This Belpaire firebox has, as is well known, been largely adopted in France and Germany as well as in Belgium; but from some cause or the other it has never gained much ground in this country. Here, however, flat-topped firebox casings have been in use for some 10 years or so on the Stockton and Darlington Railway, the present practice on that line, however, being to keep down the crown of the firebox casing to rather below the level of top of the boiler barrel, the necessity for longitudinal and transverse stays to strengthen the ends and sides of the casing above the level of the firebox crown being thus done away with. Next we find in America that the plan has been largely adopted of retaining the semicircular crown for the casing, and staying it to a flat firebox crown by stays of various lengths and different degrees of obliquity, this plan being, however, attended with the disadvantage that owing to the angle at which some of the stays pass through the plate into which they are screwed, there is a difficulty in getting thoroughly good threads. Again, on our Great Northern Railway, Mr. Stirling is now extensively adopting a modification and decided improvement of the American plan, the semicircular roof of the firebox casing being in this instance retained, but the firebox being made with an elliptical instead of a flat crown. In this arrangement the area of the tube-plate, and consequently the space available for the reception of tubes is somewhat reduced, but the advantage is gained of a form of crown which tends to keep clear of deposit, while the stays pass through the plate at much more favourable angles than when a flat crown is stayed to a circular casing, as in the American practice.

Herr Becker's arrangement, as will be seen from our engravings, and as we have already explained, differs from any of the types we have just enumerated, and we think that with a slight modification it would form the best solution of the problem. The Becker firebox may be considered as holding an intermediate position between the Belpaire and American types. As will be seen from the transverse section, Fig. 16, Plate CXVII., the roof of the firebox casing is flattened for the width required to accommodate the stays, and Herr Becker thus secures, like M. Belpaire, an uniform length for the stays and flat surfaces against which the heads and nuts can be screwed up, whilst from the stays passing through the plates at right angles good threads can be ensured. As will be also seen from the section, Fig. 16, Plate CXVII., there are but four longitudinal rows of stays, these being placed at a distance apart of $5\frac{7}{8}$ in. from centre to centre, and the total width of the flattened portion of the roof plate has thus to be but about 20 in. On each side of this flattened portion the ordinary arched form is retained, and the necessity for the transverse stays used by M. Belpaire is thus avoided, while the corners of the firebox itself are strengthened by being arched, as shown. The flattened top of the roof of the casing is also, as will be observed, at such

a level that it is flush with the barrel of the boiler, the connexion between the barrel and casing being made as shown in the longitudinal section.

In the boiler we illustrate the roof stays are, as we have said, placed at $5\frac{7}{8}$ in. centres transversely, while the pitch longitudinally is $4\frac{1}{2}$ in. In the two middle rows the stays have a diameter of 1·02 in., while in the outer rows the diameter is 1·26 in., these being the diameters in the reduced portion between the screws. The top plate of the casing is in these boilers usually made at least $\frac{5}{8}$ in. thick.

We have said that, with a slight modification, we should regard Herr Becker's as the best mode of staying firebox crowns, and this modification is that the portions of the top plate of the casing connecting the sides with the flattened crown should be curved to quadrants of circles instead of to a flatter arc, as at present. We are quite aware that this alteration would, with some proportions of firebox, involve carrying the side plates of the casing straight up to such a height as to necessitate the employment of transverse stays above the crown of the inside firebox, but we consider that the objections to the employment of these stays would, in such instances, be more than counterbalanced by the advantages obtained. To explain our reasons for holding this opinion, it will be necessary to consider the strains acting on the firebox and casing under the existing arrangement. Referring to the transverse section, Fig. 16, Plate CXVII., it is evident that the downward pressure on the central flat portion of the firebox crown is exactly equal to the upward pressure on the corresponding portion of the crown of the casing, and these two parts being directly connected by stays, they may be disregarded in considering the strains on the other parts of the shell. In other words, we may imagine a strip some 20 in. wide cut longitudinally out of the centre of the firebox and casing, and the two side portions then closed up and joined together without affecting the strains to which the plates of these laternal parts are exposed. If, then, we imagine this to be done, we should have an inside firebox with a semicircular crown of about 12 in. external radius, and an external casing of which the crown had the form of a Gothic arch, the acute angle of the latter at the apex, however, being replaced by an arc of small radius. Now such a Gothic arch, subjected to uniform internal presure, would evidently require tying together at the springing, and thus we see that a firebox casing of the form used by Herr Becker tends to spread at the junction of the arched portions and the side plates, or, in other words, throws a strain on the top rows of stays beyond what may be considered their normal load, namely, that due to the pressures on the flat surfaces they connect. For this reason we should consider that the top row of stays in Herr Becker's fireboxes should be of extra strength, or otherwise we should apprehend that they will be specially liable to fracture.

If now the crown and sides were united by quadrants of circles we should—supposing the central portion of boiler to be removed as before—have in effect a casing with a semicircular crown, and there would be no spreading strain on the side plates due to the pressure of the steam on the quadrantal portions. It would, as we have said, depend upon the proportions of the firebox and casing, or practically upon the distance between the crowns of the former and the latter, whether or not the employment of the quadrantal form for the junctions of the sides and crown would necessitate the use of transverse stays. In the Stockton and Darlington engines the form adopted is practically that we advocate, the distance between the two crowns, however, being in that case reduced by making the crown of the casing lower than the level of the top of the boiler barrel, while the radii of the corners being comparatively small, the extent of flat top surface is much greater than in Herr Becker's boilers. We should prefer, however, retaining Herr Becker's proportions for the directly stayed crown surface, as by doing so greater facility is afforded for the expansion of the inside firebox, which takes place when getting up steam. It will be seen, in fact, that if modified as proposed, Herr Becker's box would, when the distance between the two crowns was small, resemble the Stockton and Darlington pattern, whilst when this distance was large, and transverse stays were used, it would approximate to M. Belpaire's. Where the differences depend simply upon proportions, as in this case, it is difficult to say where one pattern ends and another commences.

We have just referred incidentally to the expansion of the inner firebox, in excess of that of the outer, which occurs when getting up steam. In some of the earlier examples of directly stayed firebox crowns this expansion gave trouble, owing to the rigidity of the connexion between the crowns of the firebox and casing, but the experience on the German and other Continental railways, where this mode of staying is extensively in use, shows that this trouble can be completely avoided by keeping the front and back rows of crown stays at a sufficient distance from the tube plate and back plate of the firebox respectively. This distance is now usually made not less than 6½ in,, 7 in. being a dimension very generally adopted. In concluding our remarks about the staying of firebox crowns we should add that in May 1873 there were at work on the Kaiser Ferdinand's Nordbahn 57 boilers with fireboxes of Herr Becker's pattern, whilst upwards of 200 such boilers were in use on other Austrian lines, such as the Austrian State Railways, and the Southern, the North-western, the Moravian, the Silesian, and other railways. Many engines are also running in Germany with slight modifications of Herr Becker's pattern, some of these being fitted with transverse stays above the firebox, as, for instance, in the goods engine exhibited by Messrs. Henschel and Son, the boiler which we have illustrated on Plate CI.

Returning to the exhibits in the pavilion of the Kaiser Ferdinand's Nordbahn, we have lastly to notice the form of firegrate used by Herr Becker this grate being shown on Plate CXXV.

From the views we give it will be seen that the firebars, which are of wrought iron, are simply sheared straight across at the ends, and are held in cast-iron racks carried by studs projecting from the front and back plates of the firebox. The pair of bars on each side are rivetted together, as shown, so that the extreme side bars may be kept in position.

Conclusion.

In concluding the present report it appears to us desirable that we should, to a greater or less extent, summarise the facts which were to be learnt from a study of the great variety of locomotives collected at the late Vienna Exhibition. That many hints were to be derived from such a study few English engineers who had an opportunity of visiting the Exhibition personally will feel disposed to deny, and it has been our object in this report to afford, as far as is possible by the publication of full illustrations and descriptions, the same opportunities for study to those of our readers who were unable to visit Vienna. It will, we think, be generally acknowledged that as far as materials and workmanship go the locomotives turned out by the leading German builders are fully equal to those of our own makers, although it is probable that if the average workmanship of the whole of the German locomotive manufacturers was compared with the average productions of the whole of the English firms the result would be in favour of the latter. In other words, we believe that there is a greater proportion of thoroughly first-class work turned out here than in Germany. However that may be, it is certain that the engines produced by Borsig, Schwartzkopff, Hartmann, and a few other German makers will hold their own as far as workmanship and materials are concerned with any made here, and it is no use closing our eyes to the fact. To the French, Belgian, and Austrian makers we cannot award such a high place, for although in each of these countries, and particularly in Belgium, numbers of thoroughly well-built locomotives are turned out, the general average of the workmanship is decidedly below that of Germany. In French engines especially we have noticed some wonderful specimens of fitting, particularly where frame stays and similar parts are concerned, while as regards the finish of the cleading, the flatness of the handrail plates, splasher plates, &c., and the numerous small points of finish which characterise the work of our leading English firms, the French makers are wofully deficient. It is true that the large goods engine exhibited at Vienna by Messrs. Schneider and Co. was finished in the highest possible way, thus proving the capabilities of that vast establishment; but in making these remarks about workmanship we are not thinking so much of the exhibited engines as of the locomotives we have, from time to time had the opportunity of examining on various Continental railways. As far

as materials are concerned our makers can now, we think, scarcely be considered as possessing any particular advantage—except in some cases as regards price—over their Continental rivals.

If, however—leaving materials and workmanship—we turn to the matter of design we shall find many points requiring discussion. There are no doubt certain special features of the Continental traffic, such as its very heavy character on some lines and the lower speed at which it is generally carried on, which have led naturally to special features in the locomotives employed to work it; but apart from these exceptional matters there are important differences in the construction of the locomotives employed in working traffic almost identical with that to be accommodated here, which are somewhat difficult to explain.

In the first place, speaking broadly, the inside cylinder locomotive may be said to have died out on the Continent. Such engines are still occasionally built it is true; but we have travelled for days on Continental railways without seeing a single specimen, while out of the whole 47 locomotives exhibited at Vienna there was but one with inside cylinders, namely, an Engerth engine belonging to the Austrian State Railways Company. In this country, on the contrary, a large proportion of the engines in use have always been of the inside cylinder type, while at the present time such engines are in special favour on a number of our principal lines, the introduction of steel as a material for crank axles, and the employment of inside frames only, having practically done away with the great source of trouble in former days. We have no intention of entering here into the vexed question of inside *versus* outside cylinders, but we desire to direct attention to the broad difference in this respect between English and Continental practice. Regarding the reason for this difference, it is somewhat difficult to arrive at a satisfactory conclusion, but to some extent, at least, it appears to have arisen from the demand on many Continental lines for engines of exceptionally great power. It is undeniable that when very small wheeled engines with large cylinder power have to be constructed, the retention of the inside cylinder type leads to many difficulties and disadvantages, and hence such engines have been almost universally constructed on the Continent with outside cylinders, and in a large proportion of cases with outside valve gear also? It having been found that at the moderate speeds at which such engines are run, the arrangement involved no ill-effects, a similar design has been largely introduced for classes of engines where there was really no such good reason for its adoption. To a large extent, also, the employment of outside valve gear on the Continent is due to Mr. T. R. Crampton. Of the well-known Crampton engine there are still large numbers at work doing passenger service on the Northern Railway of France and other French lines, and the influence of these engines on locomotive design can be traced in many ways, not only in France and Belgium, but also in Germany. Another English locomotive engineer whose plans have largely affected locomotive construction on the Continent is Mr. Joseph Hall, now, and for many years past, settled at Graz, whose system of engines with outside cylinders and outside frames have obtained a strong hold, particularly in Austria and Southern Germany. Such are some of the influences which have been brought to bear upon Continental locomotive design, while it may be added that the employment of external working gear, has, no doubt, been, to some extent, fostered by the fact that the construction of Continental stations, &c., permits of a width of locomotive which it would be utterly impossible to employ on English lines.

We have above referred incidentally to the influence of the nature of Continental traffic on the design of goods locomotives, and it may be well that we should discuss some of the features of these engines at greater length. The extremely heavy character of the goods traffic to be carried on some of the leading Continental railways, and particularly on some of the mountain lines more recently constructed, has in fact called into existence several types of powerful locomotives differing materially from any in use in this country. The Vienna Exhibition contained many examples of such types, illustrating the chief modes in which the Continental locomotive engineers have endeavoured to solve the problem before them, namely, how

best to produce locomotives of exceptionally great tractive power. Our present object is to speak of some of these plans, and to compare them with other modes of attaining the same ends.

In the majority of cases the locomotives built for exceptionally heavy work on the Continent are eight-wheeled, all wheels being coupled, and all axles being under the barrel of the boiler. The cylinders are outside, and in a large number of instances the engines are built upon Hall's system and have outside frames and outside cranks. The wheel base is kept as short as possible, and flexibility is given by allowing lateral play to the trailing—or in some cases both leading and trailing—axles. Such, in broad terms, are the leading characteristics of the exceptionally heavy goods engines now made on the Continent, and it is undeniable that such engines do a large amount of work at slow speeds in a fairly satisfactory way. Notwithstanding this, however, it is, we think, equally undeniable that they possess many grave defects which may be avoided by adopting another system of construction.

In the first place the necessity which exists for maintaining a short wheel base has led to the practice of putting all the axles under the barrel of the boiler, the result being an excessive length of boiler barrels and of tubes—tubes 15 ft. and 15 ft. 6 in. long being common, whilst, in some cases, the length reaches 16 ft. 6 in. To make the engines ride more easily, also, compensating beams are generally being introduced between the driving and trailing springs, and not unfrequently between the springs of the leading and second wheels also, and these compensating beams, although undoubtedly useful for reducing shocks, tend, in some cases, to reduce the control of the longitudinal oscillations or pitching motion to which the excessive overhang of the engines gives rise. Considering that the normal load on a pair of wheels in one of these heavy engines is generally between 12 and 13 tons, it is evident that the oscillations and augmentations of this load, due to insufficiently controlled pitching motion, must have a most serious effect upon the road, and most materially increase the cost of maintenance of the latter.

The true remedy for this state of things is, undoubtedly the adoption of the double-bogie system. Once let that system be adopted, and we get rid of all difficulties such as those to which we have just alluded. We can lengthen the wheel base of the engine to any desired extent, so as to obtain longitudinal steadiness, while, at the same time, we retain the utmost facility for traversing sharp curves, and especially we get rid of those variations of load per wheel due to pitching, which, in engines with great overhang, play such havoc with the permanent way. In a double-bogie engine the weight of all parts above the bogie is transmitted to the bogie pins, and is distributed over the wheels of the bogies in the proportions determined by the positions of those pins, the distribution thus effected being practically constant under all circumstances, and being only modified to an immaterial extent by the motion of the reciprocating parts of the working gear. The advantages of this state of affairs are even greater than may at first appear. If the construction of an engine is such that the normal load per axle is liable to be sometimes increased by the pitching action to the extent of 30 or 40 per cent., then in fixing the normal load this circumstance must be allowed for, and the load made less than it might be if its constancy could be insured. The double-bogie system, as we have seen, gives this constancy, and hence it follows that in an engine constructed on that system a greater load may be carried upon each pair of wheels than would be safe under other circumstances. On the other hand, also, the double-bogie system gives every facility for decreasing the load per wheel if desired. Practically, it is found undesirable to couple more than four pairs of wheels; but if we divide our power between two groups, each with its own pair of cylinders, we at once double our power of distributing the load, and can, if necessary, divide that load between 16 wheels instead of eight without incurring difficulties. Taking into account the constancy of the distribution of the load already alluded to, however, we are inclined to believe that it will be on but very rare occasions necessary to resort to eight-coupled bogies, a maximum of six wheels per bogie, or twelve in all being, we think, all that is likely to be required even for mountain locomotives, at all events for many years to come.

Another advantage of the double-bogie system attendant upon the features which we have just pointed out is that it enables us to produce tank engines for the very heaviest classes of work, and capable of carrying large supplies of water and fuel. The eight-coupled type of engine so much favoured on the Continent is quite unadapted for transformation into a tank engine, as the load per wheel in those engines is already as great as it is safe to carry under such conditions; hence these engines are made generally with a light class of tender, the weight of which, however, is always, and necessarily so, greater than that of the tanks and coal bunkers required to make the double-bogie engine carry its own fuel and water. As every ton saved in the weight of an engine—or of an engine and tender combined, if a tender is used—without decreasing its efficiency, means so much added to the useful load it is capable of hauling, the importance of this is evident.

It has been urged in some quarters that it is a mistake to carry the fuel and water on engines intended for heavy work on inclines, as the weight available for adhesion becomes reduced as the incline is mounted; the fallacy of such an argument is almost self-evident; but as the objection has been seriously advanced, it may be worth while to say a few words respecting it. It will, we think, be conceded that for very low speeds, such as are resorted to on heavy gradients, engines may be constructed in which the hauling power is limited only by the adhesion available. In other words, the boiler and cylinder power may at these low speeds always be in excess of the adhesion. This being so, it is desirable to turn to account, for increasing the adhesion, the weights of all necessary parts of the engine, amongst which the tanks and fuel bunkers must evidently be counted. If these parts be mounted on separate wheels, and thus formed into a tender, they simply increase the load to be drawn, and reduce by so much the weight of train which the engine is capable of hauling. If, on the other hand, they are carried on the engine itself, they increase its hauling power to the extent due to their own weight, and this whether they are full or empty.

There is another point in which the double-bogie system offers an important advantage, and that is, in the facility it affords for the construction of very powerful boilers carrying high pressures of steam. An examination of the large goods locomotives now being constructed on the Continent will show that the limits of steam-generating power afforded by the ordinary locomotive boiler have practically been reached. Already there are running boilers 5 ft. in diameter—a diameter which is nearly as great as can well be accommodated, while it is one which necessitates the use of very thick plates, or else a reduction of the pressure below that with which the best results are being obtained in this country. It is quite true that 5 ft. boilers may be made to stand far higher pressures than those at which they are now worked, while, of course, if necessary, $\frac{7}{8}$ in. or 1 in. plates could be employed in their construction, just as they are in modern marine boilers. But in the case of locomotive boilers the use of such plates would lead to many difficulties, and we think few locomotive superintendents would care to adopt them. If, now, the double-bogie system be carried out in its integrity, as is done by Mr. Fairlie, the engines being built with a double boiler and central firebox, we at once get rid of all difficulties about boiler power. It is evident, in fact, that this system gives us the means of producing boilers twice as powerful as any ordinary boilers now in use, without increasing the thickness of plates, or, on the other hand, if the present power be retained, it enables us to reduce the diameter of boiler barrels, and to employ plates of a more manageable thickness. It also, as will be readily understood, gives us the advantage of a constant depth of water over the firebox crown, whether the engine is on a level or on a gradient, whilst it likewise enables us to increase the firegrate area to any desirable extent without producing the evils due to overhang.

We have already alluded to the excessive length of tubes employed on many Continental goods engines, and we have pointed out that this is due to the packing of all the wheels under the barrel of the boiler. We have known it urged that this great length of tube is necessitated by the nature of the fuel consumed on many Continental lines, the long tubes being required to obtain a reasonably good evaporative duty from the inferior

class of coal available. In other words, it has been stated that the length of the tubes is not a result of the position of the axles, but that the position of the axles has resulted from the necessity for long tubes. This argument is, however, directly negatived by the practice of the engineers by whom these long-tubed engines are built, for on the very lines on which eight-coupled engines with tubes 15 ft. 6 in. to over 16 ft. long are at work we find also in use six-coupled and passenger engines with tubes of the same diameter, but 2 ft. to 3 ft. shorter. As all these engines are using the same fuel, and as longer tubes could certainly be used in the two latter classes of engines, if it was specially desirable, the natural deduction is that the tubes are shortened when circumstances permit of this being done. With the double boiler the tubes can of course be kept with the ordinary proportions of length to diameter. The subject of locomotive boiler proportions for different classes of work and varieties of fuel is, however, one on which much could be said, but it is not one into which we can enter here.

We have brought forward the above facts because we see on all hands an increase in the class of railways on which, of all others, the double-bogie system can be employed with advantageous results. Everywhere there is a tendency to build lines of moderate first cost; this desire to economise on the original outlay leading to the adoption of steeper gradients, sharper curves, and a narrower gauge, besides, in many cases, a lighter type of permanent way. By the adoption of Fairlie engines such lines can be made to accommodate an amount of traffic which is out of the question so long as ordinary locomotives are used, unless, indeed, the latter be employed to a great disadvantage. On mountain lines of more costly construction, or on other railways having to accommodate a very heavy goods traffic, the adoption of the double-bogie system would not only enable an increase to be made in the loads drawn, but would effect a most material reduction in the cost of permanent way maintenance, a matter which is but too often neglected by those having to provide locomotive power. The Fairlie system is no longer an experiment, but an established fact, and it behoves all in charge of such lines as we have mentioned, to learn for themselves the lessons which it teaches on the railways where it is in use.

In the above remarks we have referred especially to the heavier class of goods engines employed on lines having sharp curves; but we may add that in many instances on the Continent six-coupled engines with exceedingly short wheel bases are used where there are really no sharp curves to be traversed. In such instances our modern type of six-coupled locomotives with inside frames, inside cylinders, and valve gear, and with the trailing axle either below or behind the firebox, might, we are convinced, be introduced with material advantage—especially to the permanent way. In fact we consider that it is only the slow speed at which the goods traffic is worked which allows the present type of Continental engines, with their great overhang, to be tolerated, The adoption of the Hall system, too, for six and eight-coupled engines we cannot regard with favour, believing as we do that it is a system which for such engines must always give rise to heavy charges for maintenance, owing, amongst other things, to the fracture of the outside cranks.

As regards the passenger engines the remarks we have made above also apply to some, although not to so great, an extent. There are at work on many Continental lines numbers of passenger engines the short wheel base of which, combined with their great overhang laterally, would cause them to be regarded with small favour in this country; but while this is the case there are on the other hand a vast number of engines of excellent design, and of types varying but little from those regarded here as representing the best practice. Engines with a single pair of drivers are very rarely to be met with on the Continent, except on those French lines where the Crampton pattern is adhered to; but Hartmann, Koechlin, and others in Germany, as well as some of the Belgian makers have produced some very good patterns of outside cylinder engines with driving and trailing wheels coupled, which are doing good service. In a number of instances these engines have outside valve gears—in Belgium the Walschaert gear being largely used—but although this arrangement gives great accessibility we think that the

balance of advantages is decidedly in favour of placing the gear inside the frames. Many Continental passenger engines, too, are constructed on the Hall system; but as we have pointed out in our descriptions of engines exhibited at Vienna the adoption of this system involves the use of a greater weight of material in the construction of an engine of a given power than if the inside frame pattern be used, while it is also attended with other disadvantages which render it difficult to understand the favour with which it is regarded by its advocates. One point in its favour undoubtedly is, that it affords facilities for using an increased width of firebox; but in the case of ordinary passenger engines the requisite size of firebox can be got in between the ordinary inside frames, so that this advantage ceases to be of importance.

We have had occasion to allude in the course of the foregoing report to the large diameter of coupled leading wheels employed on some Continental locomotives. In this country there is a prejudice—and to a great extent a well founded one—against the running of such large wheels as leaders; but it must nevertheless be remembered that many tank engines with coupled driving and trailing wheels of large diameter, are habitually run trailing end first at speeds quite as high as those at which the Continental engines just referred to are worked. We mention this not to justify the practice of using very large coupled leading wheels—for we believe that the use of such wheels is attended with a certain amount of extra danger—but to show that the objections sometimes raised to them are to some extent contradicted by the practice of the objectors.

The application of bogies to either tank or tender engines has not as yet obtained any great hold on the Continent generally, although many bogie engines are running in Austria and in Russia. For the most part these engines are fitted with the old-fashioned centre-pin bogie, although the Bissell truck has also made its way to a small extent. The Adams bogie, which we regard as the best type yet brought out here, has not, so far as we are aware, been introduced on the Continent; at all events we have never met with it there. It is, we think, much to be regretted that this bogie was not represented at the Vienna Exhibition.

As regards details, we need say little here, as we have expressed our opinions pretty fully in describing the various engines exhibited. We may, however, allude to the excessive thickness of boiler plates, and especially of copper plates for inside fireboxes, almost universally adopted on the Continent—thicknesses which lead to disadvantageous dead weight, and which, if good material be used, are absolutely unnecessary, as the experience in this country proves. In the case of the copper fireboxes, too, the extra thickness is, we consider, a positive disadvantage in every way, leading, as it does, to a more rapid wear under the action of the fire, as shown by the short lives of the copper fireboxes on some of the Austrian lines. The large domes, generally applied to the boilers of Continental locomotives, do good service, and, although on æsthetical grounds they may be objected to, we believe that they might in many cases be used here with much advantage. As regards the working gear, there is but one fact to which we desire to allude here, and that is that the solid bushed coupling-rod ends now so largely used in this country seem, as yet, to have found no favour on the Continent. There was at the Vienna Exhibition but one locomotive having solid unadjustable bushes at the ends of the coupling rods, and even in this case the bushes were not fitted in the simple way usual here. The advantages afforded by the use of these bushes is such, however, that their adoption on the Continent as extensively as here can scarcely be much longer delayed.

We have now completed our brief survey of some of the leading features of Continental locomotives as illustrated by the Vienna exhibits, and in bringing this report to a conclusion, we can but again express our regret that English makers should have been so inadequately represented at Vienna, and that no opportunity was afforded of comparing our own and Continental practice with that of our friends on the other side of the Atlantic.

STATIONARY AND PORTABLE ENGINES.

The greater number of the stationary engines shown at Vienna were to be found in the Machinery Hall, but some were also placed (though not in motion) in each of the Agricultural Halls, while a few were also situated in separate pavilions in different places near the Machinery Hall. Without including blowing or pumping engines, which form a special sub-division the following is a classified statement, closely approximate, if not absolutely accurate, of the engines exhibited: there were about 55 horizontal engines with slide valves of the usual kind (there being included in this class three rolling mill engines) 4 small vertical engines, 4 engines with equilibrium valves of different sorts, moving vertically, 8 engines with Corliss valves, 5 winding engines, about 12 combined engines on a number of different designs, and about half a dozen examples with valves not coming under either of the foregoing heads. The number of stationary engines was in all about 90.* In treating of them here we shall subdivide them as we have done above, and further speak of the engines exhibited by each country separately; we therefore take first the horizontal engines in which the steam is admitted and cut off by means of slide valves, which, as we have said, were about 55 in number. Of the total number, four or five of the smallest had no expansion valves, eight had two cylinders, of which number two were compound, 11 were condensing engines, and two more optionally condensing, while 16 had their expansion valves under the control of the governor.

Horizontal Engines with Slide Valves.

United States.

Commencing at the western end of the Machinery Hall we found in the United States section one engine coming under the present class. This engine, which drove a portion of the machinery of its section, was one which attracted considerable attention on account of the novel features embraced in its construction. It was constructed on the plans of Mr. Pickering, of the firm of Pickering and Davis, of Portland, Con., U.S.—an engineer well known in this country from his neat steam engine governor—and in designing it one of the chief points kept in view was to do away with the bed-plate, and to resist the strains due to the action of the steam on the piston by a direct connexion between the cylinder and the crankshaft bearings. As will be seen from the engraving (Plate XLII.,) the engine has really no bed-plate, the casting to which the support for the cylinder and the crank shaft plummer blocks are bolted, being merely a light cast-iron tray to catch any oil, &c., dripping from the guide bars and bearings. The strains due to the thrust and pull of the connecting rods are taken by the guide bars, these being bolted at one end to the cylinder cover, and connected at the other end to stays, which are secured to the crank shaft plummer blocks. The flywheel runs between the two plummer blocks, while the crank shaft, which is very short, carries a crank at each end, a pair of connecting rods coupling the cranks to the crosshead, as shown.

The engine has a 6 in. cylinder with 12 in. stroke, and the piston rod is made of a piece of cold rolled iron not touched by the lathe. The valve spindle also is made of a piece of round steel used just as it left the rolls. A close examination of this piston rod and valve spindle showed that they had as good a surface, and were as perfectly cylindrical as they would have been if carefully finished in a lathe, and there can be no doubt that the use of cold rolled iron and bar steel in this way is a matter well worth the attention of makers of small engines. Mr. Pickering's engine is fitted with an ordinary slide valve, the motion being transmitted from the eccentric to the valve spindle through a rocking arm as shown. The engine is controlled by one of Mr. Pickering's governors, an arrangement which will be readily understood from the engraving. We need merely remark here, therefore, that this governor has three balls mounted on springs of thin plate steel, the deflection

* This does not include engines worked by air, gas, and any other than steam power.

of these springs as the balls fly outwards drawing down the collar to which the springs are fixed at their upper ends, and thus closing to a greater or less extent a tubular equilibrium valve contained in a valve box below. The whole arrangement is very neat, and the governor acts promptly.

A distinctive feature connected with the engine we are describing is the manner in which the power is taken off from it. To render the engine compact, the flywheel is made very narrow, and instead of being made to take an ordinary flat driving belt, it has a V-groove formed in its periphery, this groove receiving a peculiar form of driving band invented by Mr. Charles Underhill, of Tolland, Connecticut. This driving band, of which a short length is shown in the illustration, is made of leather, and is of V-section, the inner or thin edge being notched, as shown, so that the layers of leather on the broad side of the V only are continuous, and the band is thus perfectly flexible. In fact, instead of being considered as a band of V-section notched along the thin side, Mr. Underhill's driving belt may perhaps be better described as a narrow belt having fixed to its inner side a number of teeth built up of thicknesses of leather and of V-section. The pulley on the shafting to be driven is of course grooved like the flywheel, and the belt being gripped by the grooves can be run very slack without giving rise to slipping, thus reducing the strain on shafting and bearings. The band can also be lengthened or shortened as readily as an ordinary belt, and altogether Mr. Underhill's arrangement of driving gear is one which promises to do good service in many situations. The engine exhibited by Messrs. Pickering and Davis at Vienna ran steadily at 150 revolutions per minute.

Great Britain.

England was not represented by any great number of engines, but all of them fall to be described in the present sub-division, as none had any other kind of valve than the ordinary slide, though this appeared in several varieties. In the Machinery Hall the Reading Iron Works had a 25-horse power engine (17 in. diameter × 30 in. stroke) at work—a good specimen of English workmanship. It has a jacketted cylinder, and an expansion valve adjustable by hand while the engine is running, so as to vary the cut off from 2 in. to 20 in. of the stroke. The air pump is worked direct from the piston rod, the condenser being of the familiar form. The crank-shaft brasses are adjustable in two directions, a system of fitting them which seems to be rapidly gaining ground, as it ought to do. The well-known firm of W. and J. Galloway and Sons had at work one of the few compound engines in the Exhibition. This engine, which is illustrated in Plate XLII., is of somewhat unusual construction. The cylinders are bolted upon a massive hollow bed-plate, in which the guides are arranged, and on which are cast the plummer blocks for the crank shaft. The steam is admitted to the high pressure cylinder by means of plain valves working across the ends of straight ports These valves derive their motion from a slotted link driven by a small crank on a weigh shaft, which is itself driven from the crank pin by a drag link. The position of the valve block in the link is controlled by the governor, as will be seen from the engraving, and by this means the governor alters the stroke of the valves, and consequently regulates the cut off. The cranks being placed opposite each other, it is desirable that as little space as possible should be allowed between the cylinders, and these are, therefore, made to communicate simply by straight ports. Flat sliding plates in these intermediate ports regulate the admission of the steam to the low pressure cylinder, and similar plates, working on ports on the opposite side of the cylinder, regulate the exhaust. These four valves are all worked by one eccentric, through a weigh shaft and levers. The condenser is placed behind the cylinders, and the air pump is worked direct from the low pressure piston rod. It will be noticed that the high pressure crank pin is placed upon a disc on the end of the crank shaft, while the low pressure cylinder drives a double throw crank. The governor is of the approximately parabolic description, with crossed arms, and has a weight placed upon the balls. By altering this weight the speed due to the height of the governor can be varied at will, so that if it is desired to alter the normal speed of the engine, the weight alone, and not the whole governor, has to be altered.

The engine is exceedingly well put together, and its workmanship was in every way a credit to the English department of the Machinery Hall, in which it stood. The cylinders were cleaded, but not jacketted; the cleading has been removed in the engraving for the sake of distinctness. The following are the principal dimensions, &c. : —

Diameter of high pressure cylinder - -	14 in.
Diameter of low pressure cylinder - -	24 in.
Stroke of both - - - -	2 ft. 6 in.
Diameter of air pump - - -	8 in.
Stroke of pump - - - -	2 ft. 6 in.
Cut off in high pressure cylinder - -	·2 to ·5 of the stroke.
Revolutions per minute - -	60.
Working pressure - - - -	60 lb.

Mr. J. J. Derham, of Blackburn, who has made a number of steam engines for the continent, exhibited two large ones, built to work at a pressure of 100 lb. One of these, which went to a Bohemian firm at the close of the Exhibition, is 16 in. diameter by 3 ft. stroke, and is arranged to work with a condenser, for which there was unfortunately not room in the position it occupied. It has straight ports, and in consequence double slide valves. This system adds both weight and size to the cylinder, but is certainly more economical of steam than the ordinary long ports. The expansion valves work on the back of the others, and are adjustable by hand in the usual way. The second engine is on a different design, and has a cylinder 18 in. diameter by 3 ft. stroke. It also has straight ports, and in this case the valves are on the top of the cylinder, and the expansion valves are gridirons working *across* the main slides. They receive a motion by spur gearing from the crankshaft, but are also under the control of the governor, which regulates the cut off from ·0 to ·7 of the stroke. Both the engines are steam jacketted, and both have angled bearing blocks, and in both the flywheel is cast in one piece, and the boss sawn through in two places to prevent the danger of its cracking through the unequal internal tension of the cast iron. The bosses are of course hooped with wrought iron.

Messrs. D. New and Co. of Nottingham, in addition to a number of machine tools, and two small vertical engines, showed a horizontal engine of 12-horse power. It has a very neat and efficient arrangement, similar to Galloway's, but somewhat simpler, by which the governor acts direct on the expansion valve.

Messrs. Tangye Brothers, of Birmingham, exhibited at work one of their well-known 12-horse engines driving pumps, this engine being of the type illustrated in Plate XLII.

The general arrangement of this engine, which Messrs Tangye are making of various sizes of from 1 to 20-horse power, is so clearly shown by the engraving that but little explanation is necessary. The bed plate, front cylinder cover, crosshead guides, and plummer blocks for crank shaft bearing are all cast in one piece, the cylinder with its valve chest being bolted to the end of the frame as in the Allen engine. The piston rod and crosshead are of cast steel, and the blocks of the latter are adjustable, so that any wear can be readily taken up. The connecting rod has a large end of a pattern that has been much used by our marine engineers, and it takes hold of a crank pin fixed in a disc on the fly-wheel shaft, this disc being proportioned so as to counterbalance the engine properly. The crank shaft has bearings of ample size, arranged as shown in our perspective view.

An important detail of the engine is the governor, which is one designed and patented by Mr. James Tangye, a member of the firm. The construction of this governor can be best explained by reference to the detail engravings of it on Plate XLII., in which Fig. 1 is a vertical section ; Fig. 2 is also a vertical section, but taken in a plane at right angles to that at which Fig. 1 is taken, and Fig. 3 is a part plan. In these figures a a a^2 a^2 is the case of the governor and governor valve, this and the stop valve case a^2 a^2 being made in one piece ; b is the hollow vertical shaft to which the weighted arms or pendulums c c are jointed at c^2 c^2. Rotary motion is communicated to the shaft b through the bevel gearing d, shaft e, and a band passing over the pulley f, as usual. Within the hollow shaft b is a sliding shaft g, capable

of rising and falling; this shaft g is made hollow at its upper part for the purpose which we shall presently explain. Upon the top of the sliding shaft g there are projecting pieces or fingers c^3 c^3, which form parts of the arms or pendulums c c, as shown in Fig. 1, and the arms thus act upon the sliding shaft without the intervention of links or other connexions. A plan of the pendulum or arms c c, fingers c^3 c^3, and a shaft g, is represented in Fig. 3, by referring to which the shape of the fingers c^3 c^3 will be seen.

The governor valve h h^2 is double, that is, it consists of two pistons working in the cylindrical steamway i, of the case a^2 a^2. The valve is provided with a stem k, which works steam tight through the stuffing box l, and the lower part of the sliding shaft g in its descending motion presses upon the valve stalk k, and lowers the valve, and shuts off steam as will be explained presently. In the cylindrical steamway i is an annular channel m, through which channel and the passage m^2 the steam is conveyed to the engine (see Fig. 2). The steam is supplied from the boiler to the steamway i by means of the pipe n, which is opened and closed by the stop-valve p, worked by the hand wheel g. The double valve h h^2 is balanced by having holes made through its pistons, so that the steam has access to their upper sides, but the valve is supported by the steam in consequence of the area of the upper surface being diminished by the area of the valve stalk k.

When by the rapid rotation of the shaft b the weighted arms c c are caused to rise, the fingers c c acting on the sliding shaft g cause the descent of this shaft, which, bearing upon the top of the valve stalk k of the double valve h h^2 lower the latter. The upper piston h of the valve is thereby caused to partially or completely close the annular steam channel m, and passage m^2. In the engraving the upper piston h is represented in the position in which it completely closes the steam channel m. When by the cutting off of the steam the speed of the engine is diminished, the shaft g on the descent of the weighted arms c c is raised by the position of the coil spring r, and the double valve h h^2 being now at liberty to rise is raised by the steam in the steamway and the annular channel m is thereby uncovered or opened by the upper piston h^2. The use of the lower piston h^2 of the double valve we shall explain hereafter.

The arrangement of parts for adjusting the governor to act within certain limits at a greater or less speed is represented in Fig. 1. The sliding shaft g is supported by the coiled spring r pressing it upwards. This coiled spring r bears at the top against a shoulder g^2 of the sliding shaft g, and at the bottom against a cotter g^3, carried by the loose solid rod s, working in the hollow part of the shaft g. A slot g^4 is made in the shaft g, in which slot the cotter g^3 works, and the rod s^4 is screwed at top t and a screw nut works on it. By turning the screw nut t in one or other direction the rod s can be raised or lowered, the cotter g^3 rising or falling in the slot g^4, and the tension of the spring r being thus increased or diminished, and the governor thus being made to act at a greater or less speed of the engine.

The use of the second or lower piston h^2 of the double valve is as follows:—If by accident the governor is brought to rest, the steam way m being wide open, there is great risk of injury to the engine by the speed which it will thus acquire before the steam can be shut off by the stop valve p; in such case the lower or second piston h^2 rises and covers the annular channel or steamway m, and shuts off the steam. In order to prevent the complete shutting off of the steam, except in case of accident, there is provided the trigger lever u (see Fig. 1), jointed to the inner side of the governor case a, its outer arm projecting through a slot in the case.

In starting the engine the engine driver presses upon the projecting outer end of the lever u, so as to raise its inner end, as shown in the engraving. The steam being now turned on, the top of the valve stalk k comes against the lever, as indicated in the dotted lines, and the valve is thereby prevented from rising above its middle position, or only to a height insufficient to bring the lower piston h^2 of the valve over the annular steam channel m, the steam channel m being thus left uncovered, the engine is started, and the sliding shaft g descending acts upon the stalk k of the valve, and depressing the latter disengages it from the trigger lever u, this lever then falling into the position indicated in dotted lines, and not again interfering with the valve until the lever is again

raised by the attendant. The governor we have described is exceedingly well arranged, and the details, we may add, are admirably worked out; as indeed are those of these engines generally. The workmanship of the engine exhibited was very good, the castings particularly being excellent. Messrs. Tangye we may mention have at their works a well-designed series of special tools for the manufacture of these engines, and they are thus enabled to turn them out very rapidly with the aid of a very small proportionate amount of hand labour.

Messrs. Charles Powis & Co. had in the Machinery Hall a 20-horse power double cylinder engine with ordinary expansion valves, and solid throw cranks; but there was nothing about this engine requiring special notice.

In the Western Agricultural Hall, England had a number of small horizontal engines. Some of the exhibitors unfortunately thought proper to polish their engines in such a way as to take them almost out of the region of engineering criticism; and we presume the reader will scarcely be interested, to know that Messrs. Robey's engine had a bedplate with polished sides, while Messrs. Ruston, Proctor, and Co.'s had one with a scraped top, and so on. The Reading Ironworks had three very neat little engines of 2, 4, and 10 horse power respectively, the latter being jacketted; all have variable expansion gear and crank shaft bearings adjustable two ways, as well as a light and strong form of framing. Messrs. E. and F. Turner exhibited a 6 horse power engine with Hartnell and Guthrie's patent governor and wrought-iron frames. We shall describe this governor hereafter, so it is only necessary to state here that the governor revolves round the shaft, and is made to act directly on the slide valve eccentric. Its action under variable loads is remarkably quick and decided, and we are sorry that this engine was not in the Machinery Hall, where it could have been set to work. Messrs. Clayton and Shuttleworth, and Messrs. Marshall, had both small engines—the former very highly finished—which do not call for special description, but which were both distinguished by excellent design and proportions.

France.

France was poorly represented in steam engines, at least as to their number. Along with several engines for vacuum pumps the Fives Lille Company exhibited an engine which worked the shafting in the French section. It showed very satisfactory workmanship, but presented no very special points to call for remark. It had two bearings on the bed-plate, somewhat far apart, as the crank throws are angled in Λ-shape. The piston rod head worked in a single guide, the connecting rod being forked for half its length to pass over it, the expansion valve was variable by hand in the usual way.

Switzerland.

Switzerland had several capital engines; but the only Swiss machines which come within the scope of the present subdivision are two small ones exhibited by the firm of Sulzer Brothers, of Winterthur. Although the sizes of these are only 160 mm. and 200 mm. (6·29 in. and 7·87 in.) diameter × 400 mm. 500 mm. (15·748 in. and 19·68 in.) stroke, they deserve mention on account of the excellence of their design and workmanship. These engines are of the type adopted by the makers for sizes up to 10-horse power, a type which is illustrated by Plate XLIII., and Figs. 5, 6, and 7, Plate XLIV. In Plate XLIII., Figs. 1 and 2, show respectively the side and end elevation of the engine; and Fig. 3 a longitudinal section of the cylinder and valves; while on Plate XLIV., Fig. 5, is a cross section of the cylinder; Fig. 6 a section through the crosshead and slide rod guides, and the governor bracket, and Fig. 7 a complete plan.

The cylinder is cast in one piece with the valve chest, and is jacketted completely round, so that the exhaust steam does not come in contact with its sides. This necessarily lengthens the ports, but is in other respects an advantage. The jacket is cleaded with a three-fold layer of cement, felt, and wood, and the back cylinder cover is also protected by a thin cast-iron cap, an arrangement not unusual on the Continent, though we scarcely remember seeing it at home. The jacket is always in direct communication with the boiler, and the steam passes from it, through a stop valve to the slide chest. The bedplate is of a hollow section, and its construction is clearly shown in

the engravings. One end is secured to a faced flange on the front of the cylinder, and the piston rod guides are bored out in place. The main bearing bracket, which is fitted with brasses made in four pieces, is cast with the bedplate. The piston-rod head brasses are adjusted by a single screw, which is made the same size as the screw on the piston rod itself, and not—as we have too often seen in engines made by firms who should know better—about half as large. The arrangement of the slide-rod guides is somewhat unique. The guides themselves are cast-iron rectangular blocks with large surfaces. The guide for the main valve is necessarily inside, but a slot in the outer, or expansion valve, guide, allows free backward and forward motion to the boss on the main guide, which connects it with its eccentric. The main valve is of the solid-ended description, presenting on its under face the three ports as usual. On its upper surface, however, which is bored out (see Fig. 5, Pl. XLIV.), the opening s of the two steam ports are made to lie at an angle towards each other instead of being parallel. The valve is driven by a buckle forged on the spindle, and it is kept up against the valve face by the pressure of the steam. The bottom side of the valve works on double facings. The expansion valve has a turned face working in the corresponding semi-cylindrical recess on the back of the main slide. Its front and back edges lie to each other at the same angle (Fig. 3, Pl. XLIII.) as the ports on the back of the main valve. To alter the relative position of the expansion valve and the ports, or, in other words, to vary the cut-off, it is thus obviously necessary only to turn the valve round its own spindle, and it is so made that the whole range of cut-off comes within the the limits of quite a small angular motion. This motion is given from the governor—which is of the Porter pattern—by means of a simple lever connexion, the lever being keyed on to a bush through which the spindle works on a feather. This arrangement of expansion valve is that known in the United States as the "Rider cut-off." The air pump is placed inside the condenser, which is cylindrical, and is arranged vertically below the centre line of the crank shaft, and worked by a return crank. Air pump and condenser are both entirely separate from the engine itself. The feed pump is worked from the air-pump crosshead. The shape of the fly-wheel, and especially the ⊦-section of its arms, are to be commended.

At Vienna Messrs. Sulzer Brothers exhibited, as we have stated, two engines on this design, the larger having a cylinder 200 millimetres diameter by 500 millimetres stroke, and the smaller 160 millimetres diameter and 400 millimetres stroke. The particular engine illustrated is 180 millimetres (7·08 in.) diameter, and 450 millimetres (17·71 in.) stroke. It has a single-acting air-pump 140 millimetres (5·51 in.) diameter, and 185 millimetres (7·28 in.) stroke. The engine is intended to make 90 revolutions per minute, and to work with a steam pressure of 75 lbs. per square inch. The cut-off can be varied from 0 to ·7 of the stroke. The piston rod and crank pin, slide rods, &c., are of cast steel, and the main bearing brasses have white metal run in them.

Germany.

Sweden, Denmark, and Italy were almost unrepresented in stationary engines, but the German engines, to which we came next in walking up the hall, were both numerous and interesting, although the more important of them do not belong to the class of which we are now treating. The Görlitzer Maschinenbau Anstalt and Eisengiesserei Actien Gesellschaft, however, exhibited a compound engine of about 50 nominal horse power, which belongs to this class, and which is illustrated by Pl. XLV., and Figs. 9, 10, and 11, Pl. XLVI. In the former plate Fig. 1 shows a complete side elevation of the engine, Fig. 2 a sectional plan through the centre of the cylinders, while in Pl. XLVI., Fig. 9, is a section through the bedplate and guide bars looking towards the shaft, Fig. 10 a cross section of the cylinders, and Fig. 11 a section through the air-pump condenser and feed heater, looking towards the cylinders.

The engine has a bedplate of an irregular shape (but having, in most places, a ⊓ section on each side) which supports the plummer block, guide bars, and cylinders, and to which feet, projecting from the condenser, are secured. The two cylinders are cast together, the metal between them in the centre being $2\frac{3}{4}$ in. thick. The high pressure cylinder has an ordinary expansion

valve, adjustable by a right and left-handed screw, working on the back of its slide. The only peculiarity about this valve is that it is so arranged that the centre line of its spindle is in the same plane with the face of the valves, instead of being considerably above them, as of course is usual. This is managed by making the main slide extra deep, and recessing it all along the centre, as shown in the cross section Fig. 10. The cut-off can be varied from one to nine tenths of the stroke. It will be seen that the two piston rods work one crank; the steam must therefore pass direct from the front of the small piston to the back of the large one, or from the back of the piston to the front of the large one, as the case may be, without any intermediate chamber; indeed the smaller the space between the two pistons the better. The steam is carried from the high to the low pressure cylinder through a port passing under both of them, and the low pressure valve chest is made as small as possible. The valve for the large cylinder is merely an ordinary slide. The cylinders are not jacketted in any way, and they each have loose covers at both ends. It will be noticed that the stuffing boxes and glands are unusually deep; some additional depth, however, might very advantageously be added to the piston rod bushes, even at the expense of the length of the glands, as no one would work the engine with the glands almost hard up against the bottom of the stuffing boxes. The low pressure piston rod is made considerably larger than the high pressure one, a somewhat unusual arrangement, but perhaps necessary (with this proportion of cylinders) in case of the cut-off in the small cylinder being ever as late in the stroke as the gear allows it be. The low pressure piston also is the deeper of the two, this being allowed for by making the high pressure cylinder covers project further into the cylinder than the others. The two piston rods are attached to a plain crosshead, with a cast-iron guide block on each end. The guide bars are cast iron and bolted separately to the bedplate, and instead of giving the guide blocks flanges, they are each made to bear outside solidly against a third face in the guide bars, so as to take any cross strain on the crosshead. The connecting rod has gib and cottar adjustments at both ends, and is forked at the crosshead end; its position relative to the two rods will be seen from Fig. 2. Examination will show the centre of the part of the crank pin *in the crank* to be in the centre line between the two piston rods, and the wish to obtain this result has probably been the reason for the somewhat one-sided position of the connecting rod. The crank itself is one of those to which we shall have to refer hereafter, in which the crank pin end is made needlessly strong. In this case, however, the sides of the web are simply tangential to the two bosses, so facility of machining may be, to some extent, pleaded as excuse for the shape. The main bearing cover is held down by four bolts, and the brasses are adjustable in two directions. The high pressure valves are worked by ordinary eccentrics, and the low pressure valve is worked from an eccentric through the intervention of levers and a rocking shaft working in a bracket fixed on the end of the bedplate. The governor is of the ordinary kind, driven by a strap from the shaft; it drives in its turn a train of wheelwork enclosed in a case placed over the expansion valve spindle, and a lever from it (seen in Fig. 1, Pl. XLV.), by giving a small angular motion to a centre spindle, causes the gear through worm gearing to turn round the valve spindle in one direction or the other, and so alter the cut off; an index on the slipper guiding the end of the spindle (see Fig. 2, Pl. XLV.) shows what the grade of expansion is at any particular moment. The exhaust steam from the low pressure cylinder on it way to the condenser passes through a cylindrical feed heater (Fig. 1, Pl. XLV., and Fig. 11, Pl. XLVI.), through which the water passes in twelve wrought-iron tubes. From the feed heater to the condenser the steam passes through a valve by which, if it be wished, it can be sent direct to the atmosphere, and the engine worked without the condenser. The condenser itself forms a continuation of the bedplate, and serves also as an air pump seat. Fig 11, Pl. XLVI., shows clearly the relative position of the exhaust pipe and the injection cock, as well as the form of the condenser. The air pump stands immediately above the condenser, to which it is bolted. It is double acting and worked off the low pressure piston rod; the valves are ordinary india-

rubber valves on brass gratings. A cross pipe joins the two delivery valve chests, and from the centre of this an open air pipe rises. The water is delivered downwards, through separate delivery pipes into the main discharge pipe, seen in Figs. 2, Pl. XLV., and Fig. 11, Pl. XLVI. The feed pump is bolted by a bracket to the bedplate, and is worked direct from the high pressure piston rod head. It delivers the water direct into the feed heater.

The dimensions in millimetres are placed on the engraving; but it may be convenient to reproduce here the principal of them in English measurement:

		ft.	in.
Diameter of high pressure cylinder	- -	1	$0\frac{3}{10}$
„ low „ „	- -	1	$10\frac{13}{16}$
Stroke - - - - -	- -	2	$7\frac{1}{2}$
Distance between centres of cylinders	- -	1	$8\frac{1}{4}$
Distance from centre line of cylinders to bottom of bedplate - - -	- -	1	$7\frac{11}{16}$
Diameter of steam pipe - -	- -	0	$3\frac{1}{8}$
„ exhaust pipe -	- -	0	$5\frac{11}{16}$
„ air pump - -	- -	0	$6\frac{11}{16}$
„ feed pump - -	- -	0	$1\frac{5}{8}$
Stroke of both pumps - -	- -	2	$7\frac{1}{2}$
Diameter of crankshaft journal	- -	0	$6\frac{3}{8}$
Length of bearing - -	- -	0	$9\frac{7}{16}$
Diameter of high pressure piston rod	- -	0	$1\frac{5}{16}$
Diameter of low „ „	- -	0	$2\frac{13}{16}$
Length of connecting rod -	- -	7	$2\frac{5}{8}$
Diameter of flywheel - -	- -	12	$4\frac{1}{4}$
Number of revolutions per minute	60.		
Steam pressure in boilers	75.		

The machine is well made, and is as simple in its construction as an ordinary non-compound engine, and it must on this account be commended. We cannot, however, omit to point out one or two things in its design which do not seem altogether free from defect. In the first place, whether the connecting rod is placed in its present position for the reason we have before suggested, or in order that its centre line may be opposite the anticipated centre of pressure on the crosshead, we think it would be better if crank and bearing were bodily shifted so much to one side as to allow the connecting rod head to come where the crank is at present. The fork might then be made considerably smaller, and placed symmetrically between the two rods. It is probable that in ordinary working, and with a cut-off not later than $\frac{1}{2}$-in. stroke in the high pressure cylinder, the total average pressure on the two pistons will be just about equal, and so any reason for one-sided arrangements will be done away with. It would be perhaps better, although more expensive, to have a double crank and a bearing on both sides of the bedplate; but if this is not thought necessary, at any rate the side not having a bearing might be made lighter than it is. The long passage between the two cylinders will make a considerable difference in the steam efficiency unless the cut-off in the low pressure cylinder is specially arranged—as it may be—to suit large capacity of passages. Lastly, it is to be regretted for every reason except one —namely, the facility of transport—that the principal castings are in so many different pieces—bedplate, plummer block, two guides, cylinders, four covers, two slide cases and their covers, feed pump, condenser, air pump, delivery valve boxes, and so on. In order that the engine may be easily packed for shipment, these numberless pieces are often an advantage, the whole machine taking up sometimes less room in a dozen pieces than in two or three; but for all reasons connected with the machine itself it is certainly advantageous that as many of them as possible should be cast together, and that the number of joints should be as much as possible reduced. The destination of the engine must in each case determine the manufacturer how far he can go in casting the different parts together.

The firm of Decker Brothers and Co., of Canstatt (Würtemburg), besides a number of steam pumps, &c., had a 50 horse power condensing engine close

to the one last mentioned. It has a frame of the same design as the engine of Herr Wannieck's, of which we shall give full particulars when dealing with the Corliss engines. The governor is connected with a spindle running across the valve chests, and by means of internal apparatus, controls the point of cut off. The air pump is worked direct from the piston rod, in very much the same way as in the Görlitz engine just described.

Messrs. Adler and Panovsky (Paulshütte) exhibited a small engine with ordinary variable expansion gear, while the Actien Gesellschaft der Holler'schen Carlshütte, near Rendsburg, had a good double-cylinder engine at work. The cylinders of this latter engine are 460 mm. (18·11″) diameter and 840 mm. (33·07″) stroke. The flywheel is placed in the centre between the two cranks. There is no condenser, and the expansion valves are of the ordinary kind, adjustable by hand while the engine is at work. The bearing blocks are vertical and the brasses adjustable both ways. The governor, which stands between the cylinders, regulates only the throttle valves, which have also a very neat ratchet arrangement, by which their position in reference to the governor can be adjusted by hand. The sides of the bedplate are of I section. The engine is so constructed that either cylinder can be worked alone.

Almost the only stationary engine in the Exhibition which had link motion was one exhibited by the Chemnitz Maschinen-bau Verein. It is 16 horse-power nominal, non-condensing, and has no governor. The bed-plate, guides, &c., are arranged in the English fashion, and the crank is cast iron. The feed pump is worked in a neat way; it is placed on one side of the engine near the shaft end of the bedplate, and its rod passes through an eye in the end of the crosshead, and is continued to the other end of the engine and guided alongside the cylinder. When it is desired to work the pump the eye on the crosshead is connected with it by a key, when the key is not in place the eye merely slides backwards and forwards on the rod. Another Chemnitz firm, Hermann Ulbricht, exhibited a 12 horse-power engine, with a similarly arranged feed pump. It has also a neat way of communicating the motion of the governor to the cross spindle. A number of rings are turned on the movable slide of the governor, and these act like a rack on the teeth of a sector, which (in place of the usual lever) is keyed on to the spindle.

The Sächische Dampfschiff und Maschinen-bau Anstatt in Dresden had, among other machines, a small engine of about 12 horse-power, with the expansion arranged in much the same way as in Decker's engine already mentioned. In Pl. XLIV., Fig. 1 shows a side elevation of the engine, omitting only the upper part of the governor, Fig. 2 is a plan with section through the cylinder, Fig. 3 is a cross section of the cylinder, and Fig. 4 a view of the governor, upon an enlarged scale. The cylinder is steam-jacketted, the steam passing through the jacket on its way to the valve; its ends are protected by non-radiating caps placed over the covers.

The engine is fitted with an ordinary slide valve, and an expansion slide working on the back of it—the latter being arranged in combination with a Farcot's valve. Farcot's valve, it may be remembered, is generally placed upon the back of the main slide—it is not moved by an eccentric, but is carried only with the main valve by friction until it strikes certain stops, which put an end to its motion, and so cut the steam off. The stops are made movable, so that the expansion can be regulated by hand or by the governor. Such an arrangement, however, permits only a limited range of expansion to be used. The object of the additional valve adopted in the engine illustrated is to make it possible to cut off the steam at any point whatsoever during the stroke; the system is patented by the manufacturers of the engine. By means of a spindle passing through the slide chest, with a worm wheel upon its outer end, the expansion gear is placed under the control of the governor. It will be noticed that when the engine is at work the worm and worm wheel simply act like a rack and spur wheel; the worm is only used as a worm when any adjustment has to be made.

The governor, which is shown in detail in Fig. 4, is of the approximately parabolic type, with crossed arms. It is so proportioned that there is scarcely any appreciable difference in its "height" in its two extreme positions. It seems strange that this very simple method for rendering a governor practically isochronous should not be more generally adopted.

The arrangement and design of the bedplate, guide bars, &c., while somewhat ornate, do not appear so well adapted to resist the strains necessarily passing through them as the plainer but more solid forms adopted by most of the German engineers of reputation, and in this respect we think improvement might be made by judicious alteration. The engine has a cylinder 300 millimetres (11·81 in.) diameter by 600 millimetres (23·62 in.) stroke. It is intended to work at 52 revolutions, and with a steam pressure of 60 lb. per square inch.

The Berlin Union Actien Gesellschaft (late Webers) exhibited an engine with a "box" frame or bedplate, which, however, is arranged underneath the guides instead of alongside, like the Corliss frame. In its general form and arrangement this engine, which is illustrated by Figs. 1 to 8, Pl. XLVI., bears a considerable resemblance to that of the well-known Allen engine. The cylinder is bolted on to one end of a very substantial bedplate, the other end of which forms the plummer block. The guide surface is cylindrical and bored out with the cylinder, special machinery being used for this purpose, and also for insuring that the centre lines of the cylinder, and crank shaft bearing, after both are bored, lie in the same plane.

The principal novelty about the machine is the arrangement adopted for altering the cut off of the expansion slides by the governor, which differs entirely from the Farcot system formerly used by this firm, and which seems simple and likely to answer well. In order to show this valve gear completely, an elevation and section of the expansion frame, &c., is given to an enlarged scale and also a side elevation of the engine (see Figs. 5, 6, and 7, Pl. XLVI.). The main valve is of the usual construction, and the expansion valves are simple sliding plates on the back of it, the cut-off being varied by altering the distance of these plates from each other. The manner in which this motion is made constitutes the speciality of the gear. No screws are employed, but each valve has a separate spindle and stuffing-box, one lying above the other. These spindles are connected by short links with pins in a circular disc, which receives a sliding motion between guides from a separate eccentric. As long as the whole gear remains in the mid-position (as shown in the drawings) the disc receives no motion but that of the eccentrics, and the cut-off remains invariable. Its alteration is effected as follows:—Two light levers, working quite freely on pins at their outer ends (the top end of one and the bottom of the other), have oval eyes at their inner ends which encircle the above-mentioned pins in the disc. Each has also, near the middle of its length, a steel pin projecting outwards into one of the oblique slots in a sliding frame, which we may call the expansion frame. The arrangement of these slots is seen in Fig. 5, from which it will also be seen that the frame can receive from the governor a vertical motion between guides. In mid position the pin, in its oscillation, does not touch the sides of the slot, but as soon as the speed of the engine becomes too fast or too slow the frame moves up or down, the pins come in contact with the sides of the slot, the disc is compelled to turn round through a certain angle in its frame, and the valves are thus moved apart or together, as the case may be, their travel, of course, always remaining the same. The engine at Vienna was not in motion, but judging merely from inspection the whole gear is one which ought to work well, and to stand ordinary usage without having its efficiency impaired.

The mode of fixing in the front end of the cylinder, and the way in which the guide is attached to the piston rod head—especially the latter—will scarcely find, or deserve favour among English engineers. We must add also, that though the setting of eccentric rods is not a thing to be done without good reason, it still seems the better thing to do when the alternative is the constant exposure of such a large area both of cylinder and ports to the constant cooling influence of the exhaust steam.

The diameter of the cylinder of this engine is 14·57 in., and its stroke 27·95 in. It is intended to work at 55 revolutions per minute, and with a steam pressure of 75 lbs. per square inch. The cut-off can be varied to any point throughout the stroke. The workmanship of the whole was substantial without any pretension to fine finish.

Messrs. Englerth and Cünzer, of Eschweiler-Aue, showed a very heavy horizontal non-condensing engine, intended to work a rolling mill. This engine, which is shown by Figs. 1 and 2, Pl. XLVII., has a cylinder of $24\frac{3}{16}$ in. in diameter, by 2 ft. $7\frac{1}{2}$ in. stroke. It is very simple in its construction and very heavy, although in several places it appears to us that weight has been added without due regard to the obtaining a proportionate increase of strength. The bedplate is simply a flat cast-iron plate to which the cylinder, guides, and main bearing block are bolted, with a stiffening rib along each side. The holding-down bolts ($1\frac{3}{4}$ in. in diameter) are ten in number, and heavy bosses are cast to receive them. The guides are cast iron, very strong, and of an I section. The main bearing brasses are adjustable in one direction only, by four bolts passing through the cap. The cylinder was shown neither jacketted nor cleaded, but we presume it would be the latter, if the engine were at work. The centre line of the ports is made much lower than the centre line of the cylinder, so that the bottom of both is on the same level, a very good plan for getting rid of water. To get over the difficulty of the valve spindles being lower than the shaft without setting the valves at an angle (so that the eccentric rods could have a straight lead), the device has been adopted of making the valve rod guide blocks so large that they take in both centre lines, and connecting the eccentric rods with their upper corners, and the valve rods with their lower ones. This arrangement is clearly shown in the side elevation of the engine. These guide blocks themselves each occupy one side of a cast-iron bracket, and have flat bottoms and bevelled tops. The eccentric straps are of cast iron, and the rods are round. The expansion valve works on the back of the main slide in the usual way, the cut-off being adjustable by means of a right and left handed screw, while the engine is at work. The piston rod is produced behind and guided underneath, as shown. The eight arms of the fly-wheel are all made separately, and each is secured to the boss by four bolts. The outer ends of the arms are T-shaped, and each one is let into the adjacent ends of two sections of the rim (half of the T being in one section and half in the other), and fastened to them by three bolts. The diameter of the fly-wheel is 19 ft. $6\frac{5}{8}$ in., and its weight 14·892 tons. The connecting rod has an ordinary strap at the crosshead end, but a solid eye round the sank pin. The slotted opening in this eye is made larger behind than in front, so that when the key is taken out the brasses can be slid back and pulled out sideways, the hole at that place being large enough to allow their flanges to pass through. The engine was exhibited near the centre of the Machinery Hall, in the space devoted to the German exhibits. The engravings on Pl. XLVII. show clearly the depth and arrangement of foundations which are considered necessary for the engine as well as the machine itself.

In the Eastern Agricultural Hall the Chemnitzer Maschinen-bau Gesellschaft showed, with the brewery plant which we shall describe fully in its proper section, an engine of 30 horse power, with a cylinder 470 mm. (18·50 in.) diameter × 850 mm. (33·46 in.) stroke, having a well-designed main frame; the German-English Company, of Hanover, had also two engines (one double cylinder) with solid forged crank shafts, and there were one or two others of little importance.

Austria.

The Austrian exhibits of engines, as might be expected, were large. Although some engines found their way into the hall which were both faulty in design, and bad in workmanship, (a circumstance by no means peculiar to the Austrian machinery) still the general standard in both respects was very good. The well-known engineer, G. Sigl, of Vienna, Wiener-Neustadt. and Berlin, showed three engines. The largest was a double cylinder machine, constructed to work at 75 lb. per square inch pressure, the cylinders having a diameter of 20 in. and a stroke of 3 ft. 4 in. (Austrian measurement). The two smaller engines were non-condensing, 16 in. by 32 in. and 12 in. by 24 inch respectively. Their general construction and arrangement were almost precisely similar to those of the larger engine. Of this latter engine illustrations are given on Pl. XLVIII., from which it will be seen that it approaches

more to the older English type of horizontal engine than do most of the Austrian and German engines of importance. One notices especially the old-fashioned bedplate with cylinder and plummer block bolted down upon it. The cylinder has no steam jacket, and is of the common construction, with a loose cover at each end. The steam passages are shortened by making the exhaust openings double, but this necessitates contact between the exhaust steam and the cylinder wall over a somewhat large area. The valves are necessarily double to suit the ports, and their construction deserves a word of explanation. They bear a considerable resemblance to the Rider valves used by Messrs. Sulzer in the small engines already described. The main valves are of the close-ended description, and each one has on its back an open cylindrical box, of which half is cast with the valve and half bolted on, as shown in Fig. 3. The inner ends of the steam ports through the valves, when they open into this cylindrical box, are canted round at a considerable angle instead of lying at right angles to the valve spindles. The openings are duplicated on the back of the cylinder in order to assist in keeping the expansion valve in equilibrium. The expansion valves are turned outside, and work in and through the cylindrical part of the main valves; and their cut-off edges are placed at the same angle as the steam ports. A moment's consideration will make it plain, therefore, that for any given pair of positions of the main and expansion slides their relative action is the same as if the ports were in the ordinary position, while the result, which is ordinarily attained by altering the position of the latter on the former, by means of right and left-handed screws, can be reached by merely turning the expansion valve upon its own axis (which coincides with the centre of its spindle) through a small angle. This very simple motion can be given with the greatest ease direct from the governor (one of Porter's), and the gear for doing this is clearly shown in Figs. 2 and 3. The expansion eccentric is in a direct line with its valve; the main eccentric is outside, and drives the valve by means of a lever on a short weigh shaft.

The condenser, hot well, and air pump are cast in one piece, and the latter is worked direct from the piston rod. The construction of the condenser and valves is so clearly shown in Figs. 2, 4, and 5 as to render description unnecessary. Each piston rod is fitted with a cast-iron crosshead having a very large surface; the engine is intended to run only in the one direction. Return cranks are employed to drive light countershafts, from which the feed pumps are worked—a plan which scarcely seems preferable to the use of simple eccentrics. The main bearing brasses are adjustable in both directions. Light cast-iron discs, without any counterbalances, are used instead of cranks. Each engine is entirely complete in itself, and either can be disconnected or worked independently of the other. The following are the principal dimensions, &c., of the engines:—

	ft.	in.
Diameter of cylinders	1	$8\frac{3}{4}$
Stroke of „	3	$5\frac{1}{2}$
Distance of centres apart	10	4
Diameter of flywheel	14	0
Distance from centre of cylinder to centre of crank shaft	14	0
Diameter of air pump (double-acting)	0	$8\frac{1}{4}$
Range of expansion, 0·08 to 0·625 of stroke.		
Range of ordinary cut-off, 0·1 of stroke.		
Steam pressure, 60 lb. per square inch.		
Revolutions per minute	42	

The workmanship about the engines exhibited was exceedingly good.

The Fürst Joh: Liechtenstein'sche Maschinen Fabrik, &c. (Adamsthal, near Brünn), exhibited two engines, one a double cylinder engine combined with boiler, which will be duly noticed in its proper place, and one horizontal engine of 16-horse power. The main guide bars are of cast iron, and the ends arched over and keyed into bedplate, so that they cannot be easily adjusted. The expansion valve is of the ordinary variable kind, and the governor (a very complicated one, on Buss's patent) works a separate

equilibrium valve. The feed pump is worked from a sliding block in a slotted link, which receives its motion from a separate eccentric. The stroke of the pump is raised by altering the position of the sliding block, which can be done by means of a screw and handwheel. The feed pump is placed on a cast-iron foot, entirely independent of the rest of the engine.

In the pavilion of the Maschinen-bau Actien Gesellschaft (formerly Danek and Co.), of Prague, were a number of horizontal engines, including an enormous pair of about 350-horse power nominal, with gear for a rolling mill, and two winding engines, which will be described further on in their proper division.

Of the large pair of rolling mill engines just mentioned, we give engravings in Pl. XLIX. As will be seen from this plate these massive engines are fitted with spur gearing for driving a rolling mill, but as they were not shown at work the wheels which were actually in place were only wooden models of the actual gear. The following are the principal dimensions of the engines in French and English measurements:

	mm.	ft.	in.
Diameter of cylinders - -	1,100	3	7·3
Stroke - - - -	1,300	4	3·18
Diameter of crank shaft journals	375	1	2·76
Length „ „	600	1	11·62
Diameter of second shaft journals	475	1	6·7
Length „ „	775	2	6·5
Diameter of pinion - - -	2,400	7	10·48
„ wheel - - -	4,200	13	9·35
Breadth of teeth - - -	620	2	0·4
Length of connecting rod between crs. -	3,300	10	9·22
Distance between crs. of cylinders -	5,000	16	4·85

The general arrangement of the engines and the form of the bedplate is clearly shown on the engraving. One cylinder is placed at each side and works a heavy disc in lieu of a crank; the pinion is on the centre of the engine shaft, and the wheel in the centre of the second shaft, both pinion and wheel having semi-shrouded teeth. The cylinders are fixed by bolts passing through flanges and screwed into the cast-iron bedplates, a mode of fixing we certainly cannot commend. The shafts are made square for the reception of the gearing, which is further secured by two keys on each side of each square. The main valves of the engine are driven by a link motion, and on the back of these work expansion valves, the eccentrics of which do not, of course, require shifting when the engines are reversed. In the engine as actually erected there was an insufficient clearance between the crossheads of the two valve spindles, and also between the link motion and the crossheads of the expansion valve spindles—defects which would certainly have to be remedied before the engine could be put to work. The reversing is effected by a small steam cylinder fitted with compensating gear, the mode of the action of which can be seen from the side elevation. The hand lever moves the inner of two slide valves, and in this way admits steam to the cylinder, the piston rod of which is connected direct to a lever on the weigh shaft. A pin on the centre of this lever actuates, as will be seen, the outer slide valve in such a way that the steam is shut off from the cylinder and the reversing motion stopped at the moment when the reversing lever has made an angular motion exactly corresponding to that given by the attendant to the hand lever. The gear is so arranged that the relative position of the two valves to each other is always the same when they are at rest, and is such that motion of the hand valve in either direction admits steam to one or other end of the cylinder, and thus causes an up or down motion of the link.

The engine shaft brasses are adjustable both ways, those of the second shaft only vertically. The spur wheel, it will be seen, is made in halves, which are held together by 10 bolts. The bosses both of the pinion and wheel are strengthened by wrought-iron rings shrunk on.

The valve gear is arranged so that the steam can be cu off at any point between 0 and ·85 of the stroke. The engine is intended to work with a

steam pressure of 75 lb. (above the atmosphere) per square inch, and to make 100 revolutions per minute, which corresponds to the very high piston speed of 853 ft. per minute.

The same makers also showed in their pavilion another rolling mill engine, with 30-in. cylinder and 4-ft. stroke, this engine being illustrated in Pl. L. In this plate the figures show respectively, a side elevation of the machine, a sectional plan, and sections through the cylinder A B, centre of guide bars C D, end of guide bars E F, and plummer blocks G H.

The most notable point about the engine is certainly its great massiveness, but several points about its design also merit notice. The cylinder (30 in. diameter by 4 ft. stroke) is not jacketted; it has a double ported slide face, and the valve chest is cast along with it. Both the covers are loose, and have stuffing boxes fitted with brass lanterns for lubrication; and the piston rod works in brass bushes both in the glands and covers. The slide valve is of the common double-ported type, the spindle passing through a recess in the back of it; it is provided with a very broad surface on its under side (see section), which, however, is attached to the valve only by feathers. In order that the bedplate may not have to be recessed, the centre of the slide valve is made considerably higher than that of the cylinder. A plain gridiron cut-off valve works in a separate chest on the top of the other, and a cylindrical hand valve is provided (see elevation), by which the steam can be admitted to the main valve chest, either through the cut-off valve or direct, or shut off altogether when required. To the back cylinder cover is bolted a long bracket, with planed top, which serves as a guide for a cast-iron block keyed on to the prolongation of the piston rod. To the front end of this rod is attached a heavy cast-iron double eye, through which passes the crosshead, having on each end a cast-iron guide block. The connecting rod—which was a very doubtful forging bye the bye—is almost alike at both ends (the only difference being the diameter of the pin), and has at each end a strap, secured by a through bolt, with a cotter and double gib. The crank pin is placed in a cast-iron disc, which might be, but is not, made to serve as a balance disc. The crank shaft is made unusually strong, with the intended working pressure of 75 lbs. in the cylinder, it has (being 14 in. diameter) a factor of safety (against twisting stress only) of above 21. In consequence of the great thickness of the disc and length of the main bearing, the eccentrics if placed upon the main shaft would be about 18 in. out of the line of the valve spindles, and to obviate this difficulty they are placed upon a small countershaft running in bearings just behind the plummer block, and driven by a pair of equal spur wheels. The bedplate proper, which supports the cylinder and the guide bars, extends only a small distance in front of the latter, and it is secured to the casting containing the bearing bracket by four cross keys passing through a wrought-iron plate $1\frac{1}{4}$ in. thick.

It seems to us at least an open question whether the best way to construct engines for driving rolling mills and other work, where they may be exposed to sudden shocks and jars, is to strengthen them by simply adding weight everywhere, but we are aware that this is the idea entertained by most mill-owners, and that, rightly or wrongly, lighter made and more scientifically esigned engines would not sell so well as those we have alluded to. If, however, the necessity of a heavy engine be taken for granted, Messrs. Danek and Co.'s is a fair example of its class, and will unquestionably stand much rough work without injury. It is intended to work with a pressure of 75 lbs. per square inch, and a cut-off variable (by altering the position of the expansion eccentric) from ·1 to ·5 of the stroke. Its intended speed is 100 revolutions (or 800 ft. of piston) per minute, and for such an unusually high speed as this it is certainly an omission that the connecting rod is not balanced.

Complete dimensions are given upon the engraving, but we may for convenience sake repeat a few of the principal here:—

	ft.	in.
Diameter of cylinder - - - -	2	6
Length of stroke - - - - -	4	0
Diameter of piston rod - - -	0	$5\frac{1}{4}$

	ft.	in.
Length of connecting rod between centres	12	0
Diameter of crank pin	0	$7\frac{1}{2}$
Diameter of crank shaft in journals	0	14
Centre of cylinder to centre of shaft	19	$11\frac{1}{2}$
Height of centre of cylinder above bottom of bedplate	2	2

Surface of guide blocks (two)	256 sq. in.
Surface ($l \times d$) of piston rod head pin	56 „
„ „ crank pin	60 „
„ „ main bearing	294 „
Working pressure per square inch	75 lb.
Maximum total pressure on piston (allowing no back pressure)	53,010 lb.

Number of revolutions per minute, 100.

The company had also a very similar engine to that just described, but with cylinder 21 in. × 3 ft. 6 in., on the opposite side of their pavilion. This engine is fitted with a condenser, which is simply a vertical cast-iron cylinder standing above the air pump, the latter being worked by the piston rod as usual. The expansion valve is adjustable by hand, but independent of the governor. The eccentrics are arranged in the same way as in the engine last described. In the Machinery Hall the same manufacturers also showed a compound engine of about 50 nominal horse power, and this engine, which has in its design several special peculiarities, is illustrated in Pl. LI.

Its cylinders are $10\frac{3}{8}$ in. and $20\frac{3}{4}$ in. in diameter respectively, with a stroke of 2 ft. 4 in. The cylinders are placed, as will be seen on reference to Pl. LI., as close together as possible—their centres are 2 ft. apart—and are cast in one piece. The inner or working cylinders are, however, separate, and are inserted in the others, and fixed with a rust joint at each end. The cranks being set opposite each other, no steam chamber is required, but, on the contrary, it is an object so to arrange the valves and ports that a minimum of steam space shall be allowed between the cylinders, and this consideration has led to the unique valve arrangement which has been adopted in this engine. The valve faces of the two cylinders are placed at right angles to each other, and the *dip* between the sides of the cylinders is utilised in finding room for them. Besides being set at right angles to each other, they dip downwards as the longitudinal sections show, at such an angle towards the shaft as to allow the eccentrics to have a straight lead to the valve spindles. The main slide valve works on *both* the valve faces. It is a somewhat complicated casting, but it is so arranged that it both admits the steam from the valve chest to the high-pressure cylinder, conducts it from the high pressure to the low-pressure cylinder, and finally allows it to exhaust from the low-pressure cylinder to the condenser. The expansion valves, which only affect the high-pressure cylinder, work on the back of the main slide; they are of the usual construction, with right and left-handed screws, so that the cut-off can be varied while the engines are at work by means of a handwheel behind. The steam can be cut off in the high-pressure cylinder in this way from one-sixth to three-quarters of the stroke, and the cut-off remains constant at about three-quarters in the low-pressure cylinder.

The bedplate is of the shape with which we in this country are most familiar. It is prolonged on each side for a short distance behind the cylinder, when it is met by the condenser feet, which are united to it by steady pins and cotters. The piston rods have cast-iron heads, which work in slipper guides. The guide for the low pressure rod is right over the middle of the bedplate, but the high pressure cylinder quite overhangs the side of the engine, and its guide has to be supported from the side of the bedplate by brackets. The high pressure cylinder works an overhung crank, which is of course quite light, as only half the work of the machine has to pass through it. In order to save width the two eccentrics (which are cast in one) are keyed on to the boss of this crank, between its web and the outer bearing. The crank shaft bearings have been wisely both made of the same diameter (although one is somewhat shorter than the other), but the double throw

crank, which is worked by the low pressure cylinder, is made lighter on the side next the high pressure cylinder than on the side through which the strain from both cylinders has to pass. The crank shaft journals are 6½ in. in diameter. The main bearing blocks are vertical (cast along with the bedplate), with cast-iron caps, and their brasses are adjustable both ways. The flywheel is 12 ft. 6 in. in diameter, and is cast in one piece.

The condenser is very simply arranged. It is a cast-iron cylinder 14 in. in diameter by 3 ft. 1 in. long (inside) standing vertically beside the air pump. A cast-iron pipe about 2½ in. in diameter rises from the bottom about 6 in. into its interior. The mouth of this pipe is closed by a cone, the position of which can be regulated by a handwheel and screw on the top. The steam enters the condenser near the top, and the injection water is admitted through the pipe just mentioned. When the valve is a little lifted from the pipe the water spreads itself out in a thin cone right to the sides of the condenser, and the exhaust steam coming downwards is most effectually brought into contact with it, and condensed. The air pump is 7½ in. in diameter, with the full stroke of the engine; it has large gridiron valves. The hot well is cast separately and bolted on to the top of it.

The governor is of the ordinary high-speed description, with two balls. It works simply, by one long lever extending right across the cylinders, an equilibrium valve bolted direct on to the valve chest. It has no connexion with the expansion valve.

This engine altogether exhibits a good deal of originality in its design, and is both neatly and strongly constructed. The sections shown in the engravings are so distinct that no further description will be required to make them quite intelligible. The engine is intended to make 60 revolutions per minute, and to work at a pressure of 90 lb. per square inch. The shaft, cranks, and connecting rods, and also the pins in the valve motion, &c. are of steel.

Among the most notable exhibits in the Austrian section of the Machinery Hall at the Vienna Exhibition were the four engines (including a large double-cylinder horizontal blowing engine) sent by the Maschinen und Waggons Fabriks Actien Gesellschaft, in Simmering (a suburb of Vienna), formerly H. D. Schmidt. They showed good workmanship, great substantiality, and in several points originality of design. Very unfortunately, for comparison with the other engines round about them, they were not at work, so that we had no opportunity of seeing how far their performance would bear out the promise of their appearance. Of the four engines two belonged to the class with which we are now dealing, one of those being a pair of engines rated by the makers at 80-horse power, and the other a small 4-horse power engine. The 80-horse power engine has cylinders 475 mm. (18·70 in.) diameter × 950 mm. (37·40 in.) stroke, which would correspond to a total nominal horse power of about 60, according to our usual reckoning. Each bedplate has a cylinder front cast with it, which forms a hollow rectangular box under the guide, and separates into two in front to allow the cranks to work. The bearing blocks are not cast in one piece with the bedplates; they have brasses adjustable both ways. A high-speed governor stands between the cylinders, but it actuates only a pair of throttle valves, one to each steam pipe. The cut-off can be varied by a very neat arrangement of bevel gear, but this is not under the control of the governor (the reason why does not appear), and can only be worked by hand. As in Sigl's engine, the main eccentric is the one furthest away from the crank, but a very neat and simple contrivance is adopted in order to bring its motion to the centre line of the main valve spindle without having recourse to any system of levers. A short crosshead is connected at one end to the main valve spindle, and at the other to its eccentric rod, a foot, projecting from the under side of this crosshead, is guided in the usual way, while the middle of the crosshead is cylindrical, and serves as a guide to the expansion valve rod, which works through it. The condensers and air pumps are placed below the level of the floor, the latter pumps (of which there are two) receiving their motion from a countershaft worked by bevel gearing from the main shaft. The workmanship throughout this pair of engines seems very good, and their design is also excellent.

The smallest engine shown by the same firm which is called by the makers 4-horse power, is illustrated by Figs. 1 to 4, Pl. LIV. It has a cylinder 160 millimetres (6·29 in.) diameter and 320 millimetres (12·59 in.) stroke. This cylinder is entirely overhung, it has a heavy flange on its front end, and this is secured to the framing by four bolts 1 in. diameter. The end of the framing is faced and bored, and the cylinder end is made to fit the bored part for the sake of gaining additional steadiness. The back cylinder cover is enveloped by a polished cap, in order to prevent radiation, a system of construction very common on the Continent. There is but one valve, quite plain, of the ordinary description. The valve rod works in a square guide, the position of which can be accurately adjusted by means of set screws seen in the end elevation. The bedplate is of the hollow box type, and is made very strong, indeed unnecessarily so, making the engine exceedingly heavy in proportion to its power. This, however, is certainly erring in the right direction. In front the bedplate divides into two, forming a ring, and upon each side of it is cast a plummer block. The crank shaft rests in both these bearings, having a solid throw crank in the middle, and a flywheel upon each end. The brasses of each plummer block are in three pieces, and can therefore be adjusted in either direction. The guide plate forms part of the bedplate, and the piston rod head is fitted with adjustable brasses. The feed pump and the governor are both supported by brackets cast upon the cylinder end of the main framing. The governor is made approximately isochronous by crossing the arms, it works a throttle valve, placed close to the steam chest. The engine is intended to run at 85 revolutions per minute; its working steam pressure is 60 lb. per square inch, and its cut-off about three-quarters of the stroke.

F. J. Müller, of Prague, exhibited a small double-cylinder engine of about 20-horse power, about which we need say nothing, and Messrs. Friedrich and Co., Vienna, showed a small horizontal engine of anything but excellent workmanship, having an expansion valve (working on the back of the main slide) regulated by a governor, which bears a most suspicious resemblance to Hartnell and Guthrie's, which has now been known in England for several years, and through the medium of the scientific press has also become familiar to engineers on the Continent. Herr Topham, Vienna, had also an engine about which also it will be unnecessary to give any detailed description, while Herr Wannieck, of Brünn, whose Corliss engine we shall describe in its proper section, had a neat 6-horse power engine. Besides these there were in the Austrian section a few others which do not call for any mention.

Russia.

The largest engine exhibited in the Russian section, which was the extreme east of the Machinery Hall, was a horizontal engine made by G. A. Lessner, of St. Petersburg, in which what was lacking in workmanship was made up by the highly ornamental ebony and brass lagging of the cylinder. The bedplate was made very much in the English fashion, and formed a foot both for the cylinder and the condenser. For no apparent reason the valves were put on the opposite sides of the centre line of the engine to that on which the crank shaft lies. They had, therefore, to receive their motion through weigh-shafts carried across the engine underneath the guides. The governor was one of those extraordinary compounds of balls and levers, in which some engineers delight, and it controlled the expansion valve by means of an apparatus which was at least ingenious, though a severe critic might object that the same purpose might be equally well attained with about one-half the number of parts.

There were also shown in the Russian section a very interesting series of exhibits from the Imperial Technical School, Moscow. Among these two may be mentioned here, the first being a small engine made by some of the pupils while undergoing their ordinary course of training. It had a cylinder, 8½ in. diameter by 13 in. stroke, and although of course in finish it could not be compared with the machines made by the best English or German engineers, yet still the workmanship was very good, and reflected much credit on the young men, while its design also was neat and had evidently been care-

fully considered. The front cylinder cover was cast solid with the frame, which was well arranged in reference to the strains it has to resist, while underneath each point from which oil or grease may be expected sometimes to drop was cast on the frame a little trough or channel, so that the floor on which the machine stands may be easily kept clean. The ports were placed so that the level of the bottom of them coincides with the level of the bottom of the cylinder, an arrangement which considerably facilitates the escape of water. The second thing was also a "school exercise," in the shape of a model of an engine (the cylinder being about 4 in. by 6 in.) fitted with a very ingenious parallel motion. Several improvements in the design of this little machine at once suggest themselves—which more experience on the part of the students would have enabled them to correct—but the parallel motion by which the piston head is guided has certainly the merit of originality, and we illustrate it on Pl. LIV., Figs. 9 and 10, as a specimen of the results which flow from a practical school of engineering, such as that at Moscow. In the Exhibition the motion was, as we have said, attached to a working model with a cylinder some 3 in. or 4 in. in diameter; our illustration, however, shows it as part of a sectional model, which makes its construction somewhat clearer. The motion is one of those in which the stroke of the crank is only equal to half that of the piston. The piston rod *a* has in its head a pin *b*, to which are pinned two levers, *c* and *d*, with their centre lines in the same plane. The length of *c* is equal to half the stroke of the piston, and is twice the length of *d*, which carries at its other end the crank pin *e*. The lever *c* is connected by a pin with the centre of a link *f*, the extremities of which are compelled to move in arcs of circles by two radius rods *g* and *h*. The position taken up by the levers and links when the piston is in the same position in reference to the bottom of its stroke to that in which the full lines show it in reference to the top of its stroke is shown by dotted lines. The motion is of little or no practical use, for we can scarcely imagine circumstances under which it would be more advantageous to use such a complicated system of levers, with so many joints to be lubricated and so many pins to wear, than a solid guide of some kind; but at the same time the arrangement is very ingenious, and in this respect reflects great credit on its designer.

The motion was worked out and practically constructed by Mr. Malescheff, assistant in the Imperial Technical School of Moscow, the outline design, embodying its principle, was furnished by Akademiker Schebychef, honorary associate of the school.

Vertical Engines.

In the whole of the Machinery Hall there appeared to be, not including models, but four vertical engines apart from boilers, and of these one only, that of Messrs. Schneider and Co., calls for any detailed description. Two were to be found in the American section, sent by the New York Safety Steam Power Company, of which one was at work driving machines. The smaller one was called 4-horse power; it had a cylinder about 4 in. in diameter by 6 in. stroke, and is intended to run at 200 revolutions per minute, no very great speed for such an engine. It was not at work, and the most noticeable point about it was that the "bright work" about had been protected by nickel plating, a form of protective coating which is now coming largely into use in the United States, The larger engine had a cylinder 7 in. by 9 in. stroke, and was fitted with balanced piston valves. Neither of these engines compared well with some of the neat American machinery beside them.

The vertical engine exhibited by Messrs. Schneider and Co., of Creusôt, to which we have already alluded, could scarcely fail to have attracted the attention of any professional visitor to the Machinery Hall at Vienna, where it was to be found along with the other exhibits from the same firm. In reference to it we may remark that exhibitors must themselves be the best judges of how far it pays them to put superfluous work upon their machines, but that for our own part we cannot say we like to see it. The workmanship of Messrs. Schneider's engine was very beautiful, and its design, as far as outward form goes, exceedingly pleasing, but the fact that, for instance, the cast-iron standards were polished on their corners, from top to bottom, decreases

rather than increases, our admiration for the rest of the work. The engine was intended for ordinary factory work, although, in appearance, as will be seen from the views on Pl. LII., it so much resembles a marine engine; the vertical form is adopted solely to save floor space and simplify foundations. This form, however, makes the engine heavier than it need have been if the cylinders had been placed horizontally.

The cylinders are 9·45 and 15·75 in. in diameter respectively, by 23·62 in. stroke, and the cranks are set at right angles to each other. The valves are placed outside the cylinders instead of between them. The high pressure cylinder has an expansion valve worked by a separate movable eccentric, which allows a cut off as early as one-tenth of the stroke. This valve works upon a fixed plate behind the main valve, this plate being in fact the bottom of a valve chest, which is bolted on to a face on the cylinder. The high-pressure cylinder exhausts into the space around and between the cylinders, which forms a very large receiver. By means of a small circular valve high-pressure steam can, when desired, be admitted direct into this receiver, and consequently into the low-pressure cylinder. The distribution of steam in the latter is effected by a plain slide valve, and the two cylinders, it will be seen, are cast together. One of the standards forms the condenser, the air-pump being placed behind it, and worked by levers linked to the main cross-head, and two feed pumps are worked from the air-pump crosshead, the whole arrangement being identical with that so familiar to us in the early days of "steam hammer" engines on board ship. The air pump is single-acting, 9·05 in. in diameter, and with 11·81 in. stroke. The webs of the low-pressure cylinder crank, through which the whole work of the engine passes, are made (as in the compound engine of Danek's recently illustrated) stronger than those of the high-pressure cylinder crank. The governor bracket stands upon a projection cast on one end of the bedplate. The governor itself is arranged, by crossing the arms, so as to be approximately parabolic. It runs at a comparatively slow speed, and is in connexion only with a small equilibrium valve (Schneider's patent), placed outside the expansion valve chest. The other parts of the engine do not call for special remark; they will all be sufficiently understood by an examination of the views on Pl. LII.

We have before said that the workmanship shown in this engine was very beautiful, and that its design, æsthetically considered, was all that could be desired. We are sorry, however, that we cannot praise the design equally when looked at as a steam engine, instead of as a work of art. There appears to be some obvious mistakes in it, which we hope Messrs. Schneider will remedy in future engines of the same type. Few engineers who wished to attain any economy would leave without a jacket a cylinder in which high-pressure steam was cut off at one-tenth of the stroke, but the high-pressure cylinder in this engine is not only without a jacket, but elaborately unjacketted, by enveloping it in its own exhaust steam, so that, instead of receiving heat from without, it must be continually giving up heat. Of course part of this heat is utilised in the low-pressure cylinder, but the larger portion is absolutely wasted. Then, again, the size of the receiver, the capacity of which is about four and a half times as great as that of the high-pressure cylinder, is out of all proportion. We are aware that some engineers entertain the idea that an engine with cranks at right angles ought to have a large receiver, but both experiment and theory point out that a very large receiver is unnecessary, and in some respects detrimental. The pressure maintained in the receiver, and consequently the initial pressure in the low pressure cylinder, depends materially upon the point of cut off in the latter cylinder, but this cut-off cannot always be conveniently made sufficiently early to counteract the effect of an excessively large receiver. In the present instance we believe that a great improvement would be effected by reducing the intermediate receiver to one-fourth or even one-sixth of the present capacity, while the work done in the two cylinders would be more nearly equalised. As at present arranged, when the high-pressure cylinder cuts off at one fourth the stroke, the work done in it would be fully twice as great as that done in the low-pressure cylinder, if the former gave out no heat to the steam in the receiver. The governor is well designed, and sufficiently power-

ful to act with great quickness on the light valve with which it is connected, but of course such a valve only regulates the speed of the engine by wire-drawing the steam.

It will be believed that we have made these remarks in no unfriendly spirit. It is our aim to put before our readers, as far as possible, all that was noteworthy in the Machinery Hall at Vienna and faithfully to represent in our pages the state of engineering on the Continent as it was there to be seen, but we should be failing in our duty did we not point out the shortcomings, as well as the excellencies, of the machines which we illustrate.

The only other engine remaining to be noticed in this class is that of Hermann-Lachapelle who exhibited a small vertical engine of two-horse power similar to those which they exhibited combined with boilers, and of which we shall speak in their proper class.

Corliss Engines.

Of the eight Corliss engines shown at the Vienna Exhibition two came from Switzerland, one from Belgium, two from Germany, and three from Austria. Of these engines we shall speak in the order in which we have mentioned them.

Switzerland.

The largest shown was one exhibited by Messrs. Escher, Wyss, and Co., of Zurich, but it was unfortunately not arranged so that it could be set to work. It has a cylinder about 2 ft. 6 in. in diameter by 4 ft. 9 in. stroke, and is intended to work at 140 effective horse power. The cylinder is steam jacketted, and steam is also admitted to the cylinder cover. The valve gear is that known as Spencer and Inglis's, in which the cut off is effected by the governor through a trigger gear, in which a cam springs open the two arms of a steel fork, and so disengages the valve from the control of the disc. The valves are shut by a spring, while an air cylinder is as usual provided to act as a buffer. The stroke of the eccentric is increased—it is difficult to see why—by a lever before its motion is transferred to the disc. The frame is of the regular Corliss type, and very massive. The piston rod head is fitted with brasses, adjusted by two bolts, one of the very few instances of this adjustment in the Exhibition, and the pin is, of course, fast in the connecting rod. The feet are quite separate from the piston rod head, and can be set up against the guide faces by screws. There are no side guides of any kind, nor anything to prevent the piston rod turning round except the crank pin.

Messrs. Socin and Wick, of Basle, exhibited a very beautifully finished little engine with gear of exactly the same kind as Escher and Wyss's. The cylinder is 33 centimetres (13·12 in.) in diameter by 75 centimetres (29·52 in.) stroke. Although the workmanship displayed in this little machine was really very fine (its price was 11,000 francs), it is impossible not to come to the conclusion that it would be unwise to put it in charge of any one but a thoroughly skilled engineer, and even in the best of hands the inaccuracies in working caused by the inevitable wear of its minute parts would be likely speedily to destroy its special economy.

Belgium.

The Belgian Corliss engine was exhibited by Bede and Company (Société Houget-Teston), of Verviers, and was constantly at work driving the machinery in the Belgian section. It is illustrated in Pl. LIII., and Figs. 5 to 8, Pl. LIV., and it will be seen from the following description, as well as from the engravings, that it presents several points of novelty and interest. It is called 50-horse power, and has a cylinder 450 mm. (17·71 in.) diameter by metre (39·37 in.) stroke. The cylinder is made in four pieces, namely, cylinder proper, the envelop or jacket, and the end castings, which form steam chests and cylinder covers. The steam jacket, or rather steam foot cast on it. The arrangement of the valves is unique in and much to be commended. The steam valves (the upper on the end of the cylinder, the port being simply a hole d. The metal might, however, with advantage be made

somewhat thicker at this place than it actually is. The exhaust valves are placed inside the cylinder, and are made semi-cylindrical.

This arrangement has the following advantages: the steam from the boiler jackets the cylinder, both at sides and ends, the steam ports are the very shortest possible under any arrangement, and no steam room is wasted in an exhaust valve chest. It will be remembered that if the exhaust valves have, as is common, a chest to themselves, the ports must be on the further side of the chest, in order that the steam may keep the valve tight, and thus every stroke the whole of the chest not taken up by the valve (in addition to the port) must be filled with steam. With the present arrangement and shape of exhaust valve it will be seen that absolutely no steam room is lost, there not being even a port to fill with steam. The exhaust ports being on the bottom of the cylinder are in the most advantageous place for draining off water, and, lastly, the exhaust steam, being carried straight away separately at each end, comes nowhere into contact with the exterior of the cylinder. It seems to have only the one disadvantage, that the stuffing boxes, being entirely surrounded by steam, will be kept very hot. On the top of each of the end casings, just above the steam valves, a lubricator for the cylinder is fixed. The steam is admitted through a valve right above the centre of the cylinder, and this valve, as well as the cylinder itself, is completely covered in with neat wooden lagging.

The valve gear is on Bede and Farcot's patent, and differs essentially from any other Corliss valve gear in the Exhibition. In common with all the others it has springs and dash pots, "traps" as the Americans would phrase it, but the gear acts in more direct lines, and with fewer joints, than in most of the other engines. The governor stands beside the centre of the cylinder, from which its spindle *a*, (Figs. 5 and 6, Pl. LIV.,) is supported by brackets. It is driven by ordinary bevel gear from the shaft, the number of its revolutions being, of course, the same as those of the engine itself. Near the bottom end of the spindle is a cam *b*, working in a frame, to which the connecting rods of the exhaust valves are attached, thus working those valves direct, closing as well as opening them.

The special part of the gear is, of course, that employed to open the steam valves. A cam of an irregular shape *c* is fast on the governor spindle, and revolves between the two vertical sides *d d'*, of a wrought-iron frame, to which it gives a reciprocating motion, the frame being fitted with steel rubbing pieces against which the cam works. At each end of this frame are a pair of lugs carrying cross spindles *e e'*, on which work freely the brass horns *f* and *f'*. These horns have on their under sides steel projections, which catch the squares on the ends of the valve rods at the right time. By means of slender tie rods the frame is connected with cast-iron crossheads *g g'*, which form the ends of cylindrical spring boxes, as shown. It will be seen, therefore, that the frame *d*, the horns, the tie rods, and the crossheads must always move together, and that their movements are absolutely under the control of the cam *c*. The motion given by the cam is a short and rapid movement in each direction alternately, a period of almost absolute rest coming after each motion. *h h'* are air dash boxes of the usual construction, they are cast on to the bracket which supports the governor spindle, and in them work wrought-iron pistons *k k'*, forged solid with what may be called for shortness the valve rods. A very short link connecting these rods with the levers on the end of the valve spindles is sufficient to allow for the versed sine of the small arc through which they move.

The governor is Proell's patent, of which several were exhibited at Vienna. Its construction is very simple, it only differs from an ordinary governor turned upside down, in having the fulcra of the ball arms carried in the sliding block instead of being fixed. The curve described by the balls is outward and upward, and almost exactly the same as in an ordinary governor, but this arrangement is said to be more delicate in its action. It is generally, though not in this engine, fitted with a weight above the slider. The slider raises or lowers, by the rods *l* (seen also in Fig. 7, Pl. LIV.), which pass through guides in the governor bracket, a cross piece *m*, which encircles the two upper arms of the horns, and in the ends of which are stops *n*.

The following description of the action of the valve gear under notice will make it easily intelligible. When the gear is in the position shown in Figs. 5 and 6, Pl. LIV., the piston is at or about midstroke, moving towards the front of the cylinder, and the cam *c* has a left-handed rotation looked at in plan. The horn *f* is in its lowest position, and the projection (which is steel) on its under side is pressing against the square head of the valve rod, so that as the cam comes round this rod moves forward as if in one piece with the frame and cross head, and the valve is thereby opened. During this operation, of course, the length of the spring is not altered, but it remains in its normal condition, which is one of considerable compression. At the right moment for cutting off the upper arm of the horn *f* comes in contact with the stop *n*, the position of which is regulated by the governor, and it is thus prevented from moving onwards with the frame *d d'*, and turns over on its pivot *e*, through a sufficient angle to release the valve rod, which is immediately forced back by the spring into the position in which the rod *k'* is shown in the engraving (Fig. 6, Pl. LIV.), and the valve thereby shut. The piston in the dash pot merely serves the purpose of preventing jar. The valve remains in this position until the cam again brings back the frame and horn, when the latter falls into gear by its own weight, and the whole process is repeated. Those who object to springs and catch gear in any and every shape, will, of course, object also to this gear, but it certainly, as we have before said, has greater simplicity and more directness of action than any other such gear that we noticed in the Exhibition. We should add that the compression of the spring can be regulated by nuts on the tie rods between the frame and the crossheads.

The main framing of the engine is very much of the ordinary Corliss type. It forms the cover of the front steam chest, and has the guides (which are bored out) and the bearing bracket cast along with it. Between the guides and the bracket it is of an H-section. About the bracket itself there is nothing remarkable; it has brasses which are adjustable both ways, the horizontal adjustment being effected by wedges as usual. The connecting rod end is of the open jaw type which has been frequently adopted for the connecting rods of locomotives.

The air pump is cast with the condensers, and worked direct from a prolongation of the connecting rod. The injection water is admitted to the condenser near the top through the the same pipe as the exhaust, as will be seen from Figs. 1 and 2, Pl. LIII.; the discharge takes place from the opposite side near the bottom. To avoid the use of inverted valves, the latter have been placed in an oblique position, and a somewhat complicated arrangement of passages has been formed in the castings.

The flywheel, which in the Exhibition drives shafting by a strap, is 4·500 metres (14 ft. 9 in.) in diameter, and 400 mm. (15¾ in.) wide. In the engravings on Pl. LIII., Fig. 1 is a side elevation of the engine, showing the connecting rod, guides, &c., and Fig. 2 a plan, while on Pl. LIV., Fig. 5 is a sectional elevation of the cylinder, valves, and valve gear; Fig. 6 a plan of the valve gear to an enlarged scale; Fig. 7 an end view; and Fig. 8 an elevation showing the valve gear. The workmanship of the engine was good throughout.

Germany.

Of the two German Corliss engines one was shown in the Machinery Hall, and one was to be found in the pavilion in which were the ice machines and Lehmann's hot air engine. The former was exhibited by the Gräflich Stolberg Wernigerödische Faktorei, of Ilsenburg, Hartz, and it is illustrated in Pl. LV., Figs. 1 and 2. It has a cylinder 445 millimetres (17·52 in.) diameter by 800 millimetres (31·5 in.) stroke, and is fitted with the real Corliss gear, which we shall describe in detail in connexion with the next engine we notice.

The machine has three principal castings; the cylinder with the valve chambers (the front cover being cast on); the main framing of the usual hollow type and the guides and the plummer block. The valves present nothing unusual in their construction, and it being our intention to describe fully the gear of

Herr Reinecke's engine, which is almost exactly similar to that of the engine now under notice, we need only say that it appears to us that with a little arrangement the excessively long valve spindle brackets might have been shortened, with considerable advantage as regards the stability of the whole affair. The governor is a "Buss" driven by a strap. The main bearing is made adjustable both ways. The piston rod head is fitted with guide blocks of lignum vitæ (which can be packed outwards as they wear), working in V grooves. The piston rod is carried out behind, and sheathed with a pipe attached to the gland of the stuffing-box. The air-pump is horizontal and double-acting, placed in a pit below the engine, and worked through a cast iron bell crank by a connecting rod attached to the end of the crank pin. It is 200 millimetres (7·87 in.) diameter by 400 millimetres (15·75 in.) stroke, double acting, and fitted with india-rubber fly-valves. It seems, to say the least of it, singular that with every facility for the introduction of a vertical air-pump the designers should have introduced complications to get a pump in the less advantageous horizontal position. The condenser is a vertical cast-iron cylinder, placed alongside the pump, and communicating with it by a straight pipe. The engine is intended to work at 50 revolutions per minute, and with a steam pressure of 60 lb. per square inch. The cut-off varies from ·1 to ·3 of the stroke.

The Corliss engine sent to Vienna by Herr C. Reinecke, of Königsberg, was, as we have said, shown at work in the pavilion in which were the German ice and brick making machines to the north of the Machinery Hall. In Pl. LV., Figs. 3 to 6 show the engine in outline and its foundations, while in Pl. LVI., Figs. 1 to 3 show the valve gear to an enlarged scale. In Pl. LV., Fig. 3 is a side elevation of the engine; Fig. 4 a plan of the foundations; Fig. 5 is a cross section of the whole through the bedplate; and Fig. 6 a section through the flywheel pit; while in Pl. LVI., Fig. 1 is a side elevation of the valve gear and governor; Fig. 2 a plan of the same with the omission of the valve connecting rods; and Fig. 3 is a skeleton view of the gear with outline section of the cylinder.

About the engine itself we need not say much, as it does not present any special points of interest in its construction apart from the valve gear. The cylinder has a diameter of 1 ft. 5 in., and a stroke of 2 ft. 9 in. The bedplate (as will be seen from Fig. 5, Pl. LV.) is in section the shape of a Hodgkinson's beam put on its side. The air pump is worked direct from the piston rod, and is cast separately from the condenser, on the top of which it stands. The guide feet of the piston rod head (which is—we know not why—of brass) are adjustable, and the main bearing brasses are adjustable both ways. The design of the engine would be much improved, as well as simplified, if the principal castings were not made in so many separate parts. Instead of casting everything in one which could have been cast in one, the opposite plan has been apparently followed, and the castings are as numerous, rather than as few, as possible.

The arrangement of the gear for working the valves is as follows:—The eccentric rod, the length of which is adjustable, as will be seen, gives an oscillating motion to a kind of triangular disc, which vibrates on a pin fixed in the large irregularly-shaped bracket seen in Figs. 1 and 3, Pl. LVI. In this disc (we use the word because, although not circular in shape, it serves the same purpose as the circular disc in the older engines) are four pins, of which the two to the right drive the two exhaust valves through connecting rods of adjustable length. The construction of the exhaust valves is shown in Fig. 3, from which it will be seen that, as is usual, they are driven by a flattened spindle, and that the actual opening and closing takes place in the valve box upon the port furthest from the cylinder, the whole of the valve box unoccupied by the valve having to be filled with steam each stroke. The two pins on the side of the disc nearest the crank shaft give a continuous vibration to two light cast-iron vertical levers having a ⊏ section throughout the greater part of their length, and working on a pin fixed at the bottom of the same bracket as the centre pin of the disc. In the top of these levers are pins, on which work freely the horns or catches which open the steam valves. These are made of iron, faced with steel at the catch, and a small weight is placed on the front (the right hand side) of each, to insure that that end shall

always drop into gear when free to do so. The back ends of the horns are curved upwards, and work underneath a stop on a lever, the position of which is regulated by the governor, which is on Buss's patent. On the back of the vertical levers are strong steel springs fast to them at the bottom, but free at the top, and these springs are connected by short rods to the rods of the air cylinder piston, to the front sides of which are attached the connecting rods, which work the steam-valve levers direct. The action of this gear will be better understood by a reference to the left-hand steam valve in Fig. 3, which is just being opened. The vertical lever is being drawn towards the cylinder by the pin on the disc, and the catch lever on the end of it is pressing the end of the rod through which, in almost a direect line, the valve is worked, and thus opens it. This rod, being thus compelled to move, draws the spring after it along with the lever, and this motion continues until the horn is brought so far forward as to come in contact with the stop on the governor lever. When this occurs the horn is pressed down, the catch instantly released, and the spring, separating itself from the back of the lever, immediately closes the valve, the air cylinder or dash-pot preventing shock. The spring then remains stationary until the lever comes back, when the catch again falls into gear, and the whole process is repeated. The outer ends of the valve spindles are carried in brackets bolted to the bedplate, which is carried along past the side of the cylinder. The valves themselves are of the usual description, and do not call for special mention.

Austria.

In the Austrian section the Erste Brünner Maschinen-Fabriks Gesellschaft of Brünn—the same firm which put up the large pumping engines and water tower of the Exhibition—had a Corliss engine with a cylinder 13·48 in. in diameter by about 3 ft. stroke. It has similar gear to the two last named, the differences between the three being only in small details, which it is not necessary to go into here. The main bearing block is not cast in one with the frame (which has rather more sharp corners than it ought to have), but bolted to it, and its cover is held down by bolts so small that it must have been assumed that no strain of any kind was to come upon them beyond holding the keep in its place. The Karolinenthaler Maschinenbau Actien Gesellschaft (formerly Lusse, Märky, and Bernard), Karolinenthal, Prague, exhibited an engine with Corliss valves, worked by Märky and Schultz's patent gear, which appears more more compact and less likely to become rapidly ineffective through wear than the last described arrangement. The disc is placed exactly as in the Ilsengburg engine, and the exhaust valves are worked in the same way. Two hollow rams, however, about 4 in. in diameter, which are moved regularly backwards and forwards in a horizontal plane by connecting rods from the disc, take the place of the two links. Connecting rods from the levers or the steam valve spindles are jointed to the pistons of small air cylinders just in front of the rams, and from the back of these pistons rods pass right through the centre of the rams. By means of cotters moved by the governor the rods can be connected to or disconnected from the rams. When they are connected the disc governs the motion of the valves, and opens them in the usual way, but directly the connexion is severed a strong helical spring in the back of the ram closes the valve, the air cylinder, as in all the other cases, acting as a buffer. The bedplate of this engine is of the usual Corliss shape, the main bearing blocks, which are angled, being cast with it. There does not seem any reason why, with a little arrangement, much of the overhang of different parts of the gear (and nearly every single pin is more or less overhung), should not have been avoided, and if this could have been done it would have been a very great improvement. As the engine is now constructed, we fear a few months ordinary wear and tear will suffice greatly to mar the precision of its action.

The only Corliss engine now remaining to be noticed is that exhibited by Mr. Friedrich Wannieck, of Brünn, and illustrated on Pls. LVI. and LVII., the views on the former plate showing the details of the valve gear, which is constructed on Wannieck and Köppner's patent. The general construction of the engine is very clearly shown in the engravings, and is to be thoroughly

commended. The main frame of the engine—for the term "bedplate," so long used, seems to be no longer applicable—follows a design of which the visitor to the machinery hall at Vienna might see numberless examples. It is a design which ought to have been adopted long ago, but which the conservativeness of British engineers has allowed to make but slow progress in our own country, although it has been all but universally adopted abroad. Its principle is, as will be seen from the drawing, that the axis of the frame should coincide as nearly as possible with the line of the principal strain, and not be put only parallel to that line, and at a considerable distance from it, as in the old form of bedplate, Along with this improvement in the design of the framing, Herr Wannieck, in company with most of the horizontal engine makers exhibiting, has adopted the plan of guiding the piston-rod head direct, instead of fixing its guides on the two ends of a crosshead.

In reference to the construction of the framing we need only say, that its section is a hollow rectangle, rounded at the corners, and somewhat larger at the cylinder end than near the shaft. The front cylinder cover, guides, and main bearing block are all cast together in one piece with the framing. The piston rod guides are of a V shape. The front cylinder cover is secured by only six bolts (of proportionately large size), an unusually small number or such a cylinder.

The cylinder is, in Austrian measure, $16\frac{1}{2}$ in. in diameter and 36 in. stroke, which corresponds to about 17 in. by $37\frac{1}{4}$ in. in English inches. The engine is intended to run at 54 revolutions per minute. It may be convenient for our readers to recollect that an Austrian foot is equal to 1·0371 English feet, and is divided into 12 in., and these again each into 12 lines.

The valve gear merits description, which will be easily understood if in connexion with the engraving on Pl. LVI., Figs. 4 to 7. It is, as have mentioned, constructed according to the patent of Messrs. Wannieck Köppner. The object of this gear is to give to the engine a great of expansion, and consequently of power, than is possible with the usual Corliss gears; not because it is considered advisable, under ordinary circumstances, work the engine with a late cut-off, but in order that it may be able, not only to do the ordinary work of the factory with all the economy due to an early and quick cut-off, but also to develop a higher power with less expansion when press of work renders economy of fuel a secondary consideration.

In ordinary Corliss gears, it will be remembered, there is but one eccentric, which governs the three points of admission, release, and compression, and the position of which, in reference to the crank, is determined by the two latter. In Fig. 4, Pl. LVI., 1 2 represents the crank, and 2 3 the ordinary position of this eccentric in reference to it. It is obvious from this that the cut-off must take place before the crank reaches the point 4, for the motion on the other side of the centre line corresponds merely to the return of the disc over the same space which it travelled during 3, 4, and if during that time (3, 4), the valve rod has never reached the position in which it is released by the trigger it cannot do so subsequently, and the cut-off will only take place by the action of the eccentric when it has reached the point beneath the centre line corresponding to 3 above it. The general expression for the latest cut off in a Corliss engine is:—the greatest arc through which the crank can travel before the cut-off takes place, is measured by the arc between the position of the eccentric at the point of admission, and the line joining the centre of the shaft and the centre of the working pin.* In Fig. 4, Pl. LVI. this is represented by the arc 3 4, the corresponding motion of the crank being 1 5, and the cut-off can scarcely with safety be made, in any ordinary Corliss engine, later than ·375 of the stroke, Messrs. Wannieck and Köppner overcome the difficulty by using a second or cut-off eccentric, the position of which is independent of the release, &c., and which can therefore be placed opposite the crank, in the position 2 5 in Fig. 5. The arc, above mentioned, thus becomes 180 deg., so that the cut-off can take place at any point whatever during the stroke, as shown by the shaded areas in the figure. By means of a slot *b*, Fig. 6, Pl. LVI., this eccentric can be shifted through 90

* Disregarding the versed sine of the arc described by that pin as well as the lead of the valves.

deg., so as to occupy any position from 180 deg. to 270 deg. in advance of the crank. The latter position can be used when, as at Vienna, the engine has only *light* work to do.

We now leave the principle of Wannieck and Köppner's gear to look at its construction, which we shall explain by the aid of Figs. 6 and 7, Pl. LVI. The cut-off eccentric *a* gives a regular reciprocating motion to a horizontal spindle upon which are two sleeves *c* and *c'*. Collars on the spindle prevent these sleeves from moving endways (except along with the spindle), but they are perfectly free to move sideways across the spindle. They have bevelled faces on their inner side, see Fig. 7, which at the time for cut off come into contact with similar faces on the sleeves *d* and *d'*. When either *c* or *c'* is thus forced outwards, it presses out a small steel tongue *e* or *e'*, and this again acts upon the trigger *f* or *f'* (which is constantly kept against it by the spring shown in dotted lines), and pressing it outwards releases the rod *g* or *g'*, upon which the spring *i* or *i'* (which is provided with the usual dash pot), instantaneously closes the valve. The sleeves *d* and *d'* are entirely under the control of the governor, the connexion (by double levers and spindles) being such that they always move in opposite directions. A very neat arrangement of two small toothed sectors is used to give the cross spindles of the governor gear equal and opposite angular motions for this purpose. The exhaust valves are worked in the usual manner, and the waste of steam space in them is reduced to a minimum.

While it must be admitted that Messrs. Wannieck and Köppner's gear possesses considerable complication, it is also beyond doubt that there are [illegible] circumstances in which it is very convenient to have an engine possessing [illegible]ry great range of power so as easily to meet special emergencies; and in [illegible] circumstances, if the factory owner wishes to have Corliss gear at all, [illegible]l be clearly to his interest to use such a modification of it as we have [illegible]ed.

[illegible] off one crosshead [illegible] air pump [illegible] by means of a bell-crank lever. The hot well is arranged above [illegible] The condenser is a very neat arrangement; its construction is clear [illegible] shown dotted lines) in Pl. LVII. The water passes up through the inner cylindric box or tube, and is introduced into the condenser by a conical valve at the top of this tube. On the opening of the valve it spreads itself out in a shee right across the path of the exhaust steam, which ought to be fully condense before it reaches the bottom of the condenser. Judging merely from the construction of the condenser, and the way in which the water is brough into contact with the steam, it appears that a very good vacuum ought to b produced and maintained. We should, however, have preferred a vertica position for the air pump.

The Corliss valves are of the usual construction, of cast iron, with bras spindles. The valve covers and chests, as well as the back cylinder cover are polished, and the cylinder is ornamentally cleated with ebony. Th governor stands on a very neat polished iron pillar, through which its spindl works. It is sensitive in its action, and is provided with a small wate cylinder (the piston of which is connected with the rod on the right-han side of the pillar in the elevation) to prevent too rapid or jerky motion. Th flywheel is made in halves, and has wooden mortice teeth; but at the Exhibi tion the engine was not used for driving anything.

Engines with Double-Beat Valves.

Apart from winding engines there were only three engines of any impor tance in the Exhibition in which the admission of the steam was regulat by double-beat equilibrium valves. First among these came the large eng of Sulzer Brothers, Winterthur, Switzerland, of which a side elevation plan are given on Pl. LVIII., while on Pl. LIX. will be found a transverse tion, together with detail sections of the cylinder, and some indicator diagrams.

For some years past Messrs. Sulzer Brothers have been introducing special type of horizontal stationary engine which has gained for itself a hi reputation on the continent, both for its economy and for the efficiency of automatic variable expansion gear. Before describing the particular eng illustrated, we may say that the leading characteristics of the Sulzer engi

—whether of the condensing or non-condensing class—are the arrangement of the valve gear, and the construction of the valves themselves, the design of the latter being based in fact, upon the principle of the ordinary equilibrium double beat Cornish valve. The cylinder is provided with a distinct admission and education valve at each end, of which the former valves are placed under the control of the governor in such a manner that a correct steam admission, varying from 0 to 70 per cent. of the stroke, is obtained.

All the valves derive their movements from one shaft, which is driven direct from the crank shaft by means of bevel gear, and which is placed in a position parallel to the axis of the cylinder. This shaft likewise imparts motion to the governor by spur wheels; the manner in which the point of cut off is determined by the action of the governor will be presently explained in our account of the engine which forms the subject of our engravings, and which we should mention is fitted with a 17$\frac{23}{32}$ in. cylinder, having a stroke of 3 ft. 5$\frac{3}{8}$ in. Referring to the general views on Pl. LVIII., and Fig. 1 on Pl. LIX., it will be noticed that the frame of this engine is made of the hollow box pattern, as extensively adopted by Corliss, Babcock and Wilcox, and other well known American makers. The advantages of hollow box frame are that it offers a strength and rigidity that cannot easily be obtained with the ordinary bed frame; the frame forming, in fact, a kind of distance piece extending in a direct line from the cylinder to the crank shaft plummer block. The guide bars for the piston rod crosshead are formed by the frame itself, and we may add that Messrs. Sulzer shape the guiding surfaces cylindrically, in order to enable them to adopt the convenient plan of boring out the guiding surfaces in the same axis with the cylinder. There are ample guiding surfaces provided for, and the cast-iron crosshead blocks, are made adjustable so that wear may be easily taken up. The crosshead itself, as well as the crank and crank shaft, are made of the best wrought iron, while the piston rod, crank pin, and the greater part of the valve gear consist of cast steel. The crank shaft bearings are made of brass lined with white metal, and they are arranged in four pieces, which can be readily adjusted. The connecting rod is 8 ft. 7$\frac{1}{2}$ in. long between centres, and is fitted with strap ends of the ordinary description.

The arrangement of the cylinder, steam, and exhaust passages, &c., is shown by Figs. 2 and 3 on Pl. LIX. The cylinder is, as we stated, 17$\frac{23}{32}$ in. in diameter, fitted for a stroke of 3 ft. 5$\frac{3}{8}$ in., and its axis is about 2 ft. 2$\frac{1}{2}$ in. above ground level. Steam jackets are applied both along the barrel and at the ends, and the barrel is, moreover, coated with a threefold envelope, made up of cement, felt, and wood. The cylinder is supported by a hollow bracket, open at the sides, and made of the form shown in Figs. 2 and 3, Pl. LIX., and in the general views on Pl. LVIII. The diameter of the steam pipe is 4$\frac{1}{8}$ in. inside, and that of the exhaust pipe, leading to the condenser 5$\frac{3}{8}$ in. The steam we may add traverses the jacket on its way to the cylinder. Turning now to the general arrangement of the valve gear as designed and patened by Messrs. Sulzer we refer for that purpose to Fig. 2 of Pl. LVIII., and Figs. 2 and 3 of Pl. LIX., which show that the admission and the exhaust valves which are placed at the upper and at the lower part of the cylinder respectively, derive their alternate movements from a shaft revolving alongside the cylinder, and which is driven direct from the crank shaft by bevel gear, as we mentioned at the commencement of this notice. Upon this motion shaft are fixed two eccentrics, and two cams, which actuate the valves in the following manner:—As regards the exhaust valves they receive their invariable motion merely from the cams and valve rods in such a way that they are opened and closed regularly at a certain fixed point of the stroke dependant upon the position and throw of the cams by which they are driven. It will be observed on examining the cross section, Fig. 3, Pl. LIX., that the shape of the cams is such that the exhaust valves are quickly opened, and that they remain constantly open during the whole duration of the stroke, when they are again quickly closed by the action of the spring placed below the valve-spindle guide. The arrangement of these valves allows any water which may collect in the cylinder to escape freely.

In the case of the steam valves, however, which are moved from the eccentrics and rods, the arrangement is different. As will be seen, the admission

valves are worked by the action of the eccentrics in such a manner that were the point of cut-off not placed under the control of the governor they would be opened and closed in a similar manner to the exhaust valves. But in order to obtain the advantages of an automatic variable expansion gear, dependent in a comparatively simple manner upon the action of the governor, Messrs. Sulzer have devised the ingenious arrangement represented by the cross section Fig. 3, Pl. LIX. According to this plan, a second short shaft is placed between and parallel to the cylinder and motion shaft, the governor acting upon this regulating shaft by means of a rod and lever. Upon the short shaft above mentioned are fixed two levers, which are connected to steel sliding blocks, so that these latter are pulled to and fro, according to the movement of the regulating shaft. The sliding blocks just mentioned bear against steel edges, which are fixed between the eccentric rods, and which press upon the blocks when the eccentrics move, thus opening the steam valve by means of the fork, bell crank, and rod shown. Thus the amount of opening and the point in the stroke of the piston at which the valves are again shut, depends entirely upon the duration of the plane surface contact between the sliding blocks, the downward pressure on the governor rod, tending to force them out of contact. In the engine we are describing, the regulating power is furnished by one of Porter's governors, the action would, however, remain essentially the same if any other governor of equal sensibility was employed.

From the arrangement just described it will be understood that if the speed of the engine increases after the steam valves have been lifted to a certain extent, the governor acting through the rod and levers, above mentioned, causes the sliding blocks to disengage, when the valves are suddenly released and simultaneously closed by the action of the springs; this operation of controlling the steam admission varies, according to the speed of the engine and the consequent position of the governor, within the wide range of from 0 to 70 per cent. of the length of the stroke. The valves being in equilibrium, or approximately so, open and shut promptly, and almost noiselessly, on account of the air cylinders placed upon the top of the valve spindle guides, the air serving as a cushion to soften the fall of the valves.

The valves and the faces are made of very hard cast iron, prepared specially for this purpose, and the faces, being distinct from the cylinder casting, can be readily removed for examination and repair when this should be found necessary. Experience with such valves has shown, however, that the wear is almost imperceptible, and that being once carefully fitted, such valves keep at a moderate speed much better steam-tight than ordinary sliding and vibrating valves. All parts of the valve gear (which is placed wholly externally) are likewise as accessible as in the best arranged Corliss engine; and a point worthy of special mention is the position of the valves immediately upon the body of the cylinder, the object being to reduce the waste steam spaces to a minimum.

The general arrangement and the construction of the air pump and of the condenser, as applied to this engine, is shown by the general views on Pl. LVIII. From these it will be noticed that the piston rod is carried through both covers of the cylinder, that end of the rod which projects through the back cover being attached to the piston rod of the air pump, which latter has a diameter of $7\frac{3}{32}$ in. and of course the same length of stroke as the cylinder, viz.: 3 ft. $5\frac{3}{8}$ in. The injection pipe has a diameter of $2\frac{1}{2}$ in. and the discharge pipe of $5\frac{7}{8}$ in. inside. The air pump valves are of india-rubber.

The toothed fly-wheel has a diameter of 14 ft. $10\frac{1}{4}$ in. measured on the pitch line, the pitch being $2\frac{1}{2}$ in. and the corresponding number of teeth 220. The position of the fly-wheel which gears into a mortice-wheel is shown by the general views on Pl. LVIII., and referring to these views, it will be observed also that the foundation of this engine forms beneath the cylinder and condenser a spacious pit, 5 ft. 5 in. deep; this and the peculiar shape of the frame admit at all times ready access to all the working parts of the engine.

No experiments on the steam engines exhibited were made at Vienna; but tests of the Sulzer engine carried out elsewhere show exceedingly good results, and about these we desire to have something more to say. The particular engine which we have described develops 70 effective horse-power (or a useful effect of 85 per cent.) as measured with the friction dynamo-

meter and running at a speed of 50 revolutions per minute, with a steam pressure of 75 lbs. per square inch; this pressure being indicated at the engine end of the steam pipe. We are informed that from a series of various observations with an engine of this size, the average quantity of water consumed per indicated horse-power per hour, has been found to be just 8·5 kilogrammes = 18·7 lbs. The corresponding quantity of coal used amounted to 0·976 kilogramme = 2·15 lb., thus the feed water evaporated per pound of coals consumed, must have been in this case $\frac{18 \cdot 7}{2 \cdot 15} = 8 \cdot 7$ lb. The quantity of water or steam used, is, however, the real co-efficient denoting the efficiency of construction, or the economical value of a steam engine, and the consumption of but 18·7 lbs., stated to have been attained in this case, we cannot but consider as extremely low for a non-compound engine. It would be most interesting if Messrs. Sulzer would check these results by measuring the units of heat discharged with the condensing water on the system introduced by Mr. B. W. Farey, and Mr. B. Donkin, junr., a system which we regard as the best yet introduced for testing engines, on account of the facilities it affords for obtaining strictly accurate results. The indicator diagrams, shown in Figs. 4, 5, and 6, Pl. LIX., have been obtained with engines of the same size as the one above described, and we reproduce them from the originals in our possession, in order to show the correct distribution of steam effected with this arrangement of valve gear. The vacuum, however, is not as good as it should be.

The diagrams shown in Fig. 5, Pl. LIX., were taken, amongst a great number, from a pair of each of 200-horse power engines, when running at the normal speed of 40 revolutions per minute, and with a steam pressure of 70 lbs. per square inch; steam being cut off at 10 per cent. the length of the stroke. These engines are at work at a large mill at Augsburg, Bavaria.

A smaller engine of somewhat different design, but with similar valve gear to that of the engine last described, was exhibited at Vienna by the Maschinen Fabrik Augsburg, Bavaria. Of the valve gear of this engine it is unnecessary that we should repeat any detailed description, but of the engine itself, of which perspective views are given on Pl. XLVII., and of the principal features of the gear as applied in this case we may say a few words.

The valves, we may remind our readers, are four in number—two induction and two eduction—and are of the ordinary double-beat equilibrium type. The steam valves are placed on the top of the cylinder, and the exhaust valves below it. A spindle running along the back of the bed-plate is driven off the crank shaft by bevel gearing; it drives the governor in the same way, and also, by means of two eccentrics, opens the steam valves. Cams on the same spindle, close to the eccentrics, open the exhaust valves, which are closed by spiral springs, and kept closed also by the pressure of the steam. The arrangement for closing the steam valves is under the control of the governor as follows: The connexion between the rods of the eccentrics above mentioned, and the levers which directly operate upon the valve spindles, is not rigid, but is effected by the contact of steel edges in the former with steel sliding blocks connected with the latter. These blocks are entirely under the control of the governor, which it will be seen is of the approximately parabolic description, and the length of the contact which it permits between them and the edges before mentioned, determines the cut off. The actual closing of the valves is effected by means of spiral springs, the boxes of which are each furnished with a small air cylinder as a buffer. The steam is admitted to the jacket near its under side, and passes through it on its way to the valves, to which it is admitted by the stop valve shown on the top of the cylinder.

The bedplate is of the usual Corliss type, and well designed; the piston rod guides are bored out, and the head, which is, as usual, made separate from the rod, has its brasses adjustable by two bolts. The connecting rod is of somewhat unusual design, being flattened on each side from the head downwards for a considerable portion of its length, and the air pump rod is made in the same way. The crank itself, like many others at Vienna, has a considerable amount of unnecessary width at the small end. The air pump is made in a casting entirely separate from the engine; it is placed at an angle, and worked

by an eccentric on the crank shaft. The exhaust pipe from the cylinder is connected with a larger pipe lying horizontally, and leading to the air pump; this pipe serves as the condenser, a jet of water being introduced into it at the back end.

The diameter of the cylinder is 345 millimetres (13·58 in.), and its stroke 740 millimetres (29·13 in.). The engine is intended to work at 62 revolutions, and with steam up to 90 lb. pressure per square inch. The valves will cut off at any point up to ·75 of the stroke, as may be rendered necessary.

For a fuller account of the valve gear we must refer to our account of the Sulzer engine last described. We need only say further here that it is as accessible as, and not more complicated than, any well arranged Corliss gear, and that, as far as the gear is concerned, it will work quite as accurately and almost noiselessly. The capacity of the ports, notwithstanding that the valves are placed very close to the cylinder, will be a little greater than in most Corliss engines. The economical success of the whole arrangement—the efficiency of the gear being admitted—depends upon the tightness of the valves, and we believe no experiments have yet been made which can really settle this point, although the number of Sulzer engines which have been sold, and are in use, is, of course, so far evidence in their favour. The engine we have been describing is neatly and substantially made.

The last engine we have to describe in this class is one of very substantial and workmanlike design exhibited by the Sächsische Maschinenfabrik-zu-Chemnitz (formerly Richard Hartmann). Of this engine engravings are given on Pl. LX., Figs. 1 to 4. This engine was not in motion, and was without condenser or air-pump; in our engravings, however, it is represented complete, as it would be arranged so soon as it was set to work.

The general design of the framing is similar to that used in most Corliss engines, the plummer block being cast along with the frame, and the cylinder bolted on to a flange upon the end of it. The whole weight of the machine rests upon the brackets under the plummer block and the cylinder. The end of the framing nearest the cylinder is bored out for guides. The mode in which the connecting rod head is made is somewhat unusual. Instead of a solid end embraced on each side by the jaws of a strap, the connecting rod itself is made with two jaws, and a crosspiece dovetailed and bolted into the open space at the end. The eye thus formed is fitted with brasses and key as usual. The air pump and condenser are placed together in a pit below the engine, and are worked off a return crank through a cast-iron bell-crank lever. The feed pump is placed on the same centre line as the air pump, and serves as a guide for its rod. This is another instance in which special arrangements have been made to introduce a horizontal air pump when a vertical pump would, we consider, have been better.

The most interesting part of the engine, however, as of so many of the engines at the Vienna Exhibition, is the valve gear and valves. In general design the gear resembles that of the Messrs. Sulzer, of Winterthur, described above; the details of its arrangements, are, however, entirely different. The general principle of it is the same as that of the Corliss gear, namely, that the motions of the induction and eduction valves are quite distinct, and that while the lead is kept constant for all grades of expansion, the closing of the induction valves, or cut-off, is entirely under the control of the governor.

There are two induction and two eduction valves, all of the Cornish double-beat type; the former are placed above the latter, and all four open upwards. They have narrow flat, not bevelled, faces. They receive motion from a small shaft placed alongside the cylinder, which, in its turn, is driven by spur gearing from a horizontal shaft extending along the whole length of the engine, and driven from the crank shaft by bevel wheels. This shaft runs about twice as fast as the crank shaft, and gives motion, by a pair of mitre wheels, to the governor, which revolves faster still. The speed of the shaft from which the valves are worked is reduced, so as to be the same as that of the crankshaft.

The way in which each induction valve is worked will be easily understood by a reference to the enlarged elevation and cross section of the cylinder on Pl. LX., Figs. 3 and 4, and is as follows: A small eccentric upon the working shaft gives a continuous reciprocating motion to a lever consisting of two plates

of iron with a space between them. The end of this double lever furthest from the eccentric passes freely through a slot in the valve spindle. Between the two plates of the lever, and pivotted upon a pin placed directly over the centre of the valve, is a steel angle piece, or bell-crank, of which the horizontal arm lies towards the eccentric, while the vertical arm hangs downwards between the sides of the lever, and has a projecting catch on its lower end. Across the slot in the valve spindle is placed a little steel bar, and while the valve is being opened the projecting catch just mentioned is kept underneath this bar by a light spring. Just over the two double levers there runs a light spindle, which passes along as far as the governor, and is connected with it by levers of the ordinary kind. Upon this spindle, and immediately over the centre space of each of the levers, is fixed a little arm in such a way that when the inner end of the lever is raised the horizontal limb of the angle piece shall be brought into contact with it. The position of this arm is of course regulated entirely by the governor. The eccentric in the engraving is shown descending, the catch in gear, and the valve consequently just going to be lifted open. When the eccentric gets down a little further, however, the horizontal limb of the angle piece, which has of course been carried up with the lever, comes in contact with the arm on the governor spindle, and as the lever still moves upwards, the other limb of the angle piece is pressed out of gear, and the valve is closed at once by the pressure of a spiral spring in the box above it. The lower end of this box is an air cylinder to prevent shock. The two exhaust valves are worked by cams placed beside the induction valve eccentrics. They are closed by means of springs similar to those which shut the steam valves. There does not seem any reason why this should not work as well as the Sulzer gear, and in some respects it is more snugly arranged; but as the engine was not at work we had no means of making any proper comparison. The governor itself was a "Porter," with the improvement that the upper ends of the arms were crossed, the only case we noticed in which this was done in a Porter's governor.

The following are the principal dimensions and particulars of the engine, which was rated by the makers at 100 horse power:

	metres.	ft. in.
Diameter of cylinder - - - -	0·680	2 2·77
Stroke - - - - -	1·300	4 3·18
Diameter of steam pipe - - -	0·160	0 6·29
„ exhaust pipe - - -	0·180	0 7·08
„ air pump - - -	0·380	1 2·96
Stroke of air-pump - - -	0·550	1 9·65
Diameter of fly wheel - - -	5·228	17 1·83
„ crank shaft - - -	0·290	0 11·41
Cut-off (in fraction of stroke) - -	·0 to ·8	—
Steam pressure - - - -	75 lb.	—
Revolutions per minute - - -	38	—

ENGINES WITH MISCELLANEOUS ARRANGEMENTS OF VALVES NOT INCLUDED UNDER THE PRECEDING HEADS.

There were at Vienna some half dozen engines which could not correctly be placed in any of the classes we have previously described, and among them some of very great interest. The American horizontal engine 12 in. by 24 in.—to which we have previously alluded as having been built complete from the pig and bar iron in three weeks—was fitted with balanced piston valves to cut off at ·6 of the stroke. It was made by the Norwalk Iron Works, South Norwalk, Connecticut. Its framing, which is not unlike the Corliss framing in appearance, but is not hollow, has the peculiarity that the cylinder itself, and not only the front cover, is cast along with it. The bearings are placed at an angle, but the bracket which supports the outer or separate bearing is made with awkward curves not well adapted to withstand either vertical or longitudinal stress. The governor is on Pickering's patent, which

seems to give great satisfaction, as it was used on all the American engines at Vienna. The crank of the engine just mentioned is of cast iron.

The only "special" engines in the English section were Messrs. Brotherhood and Hardingham's patent three-cylinder engines and Field and Cotton's direct expansion compound engine, the latter being represented by a model exhibited by Messrs. Whitley Partners, of Leeds. Of the former engines two were exhibited, one alone, and one driving a Boulton and Imray's "helical" pump. Both these arrangements are illustrated in Pl. LXXVI., Figs. 2 to 6, from which it will be seen that in these engines three cylinders are arranged at angles of 120 deg. with each other, around a central chamber, with which they communicate, the whole being cast in one piece. Each cylinder has its own piston and connecting rod, the three rods taking on to one common crank. The crank pin, after passing through the connecting-rod eyes, is prolonged, and fits into a hole in a rotary slide valve, which it thus actuates. The valve has a steam and an exhaust port, which are alternately placed in communication with the passage belonging to each cylinder. In working this engine steam is admitted to the central chamber, and exerts an equal pressure on the inner sides of the three pistons. Thus far the machine would be in equilibrio. But steam now passes through the slide valve to the outer side of one piston, thus throwing that piston into equilibrium, but the three pistons collectively out of equilibrium. In other words, it renders the pressure on the inner sides of the other two pistons effective. A rotary motion of the crank and slide valve ensues, and the other pistons are alternately operated upon in a similar manner, the constant effective area for pressure being that of a piston and a half. If steam be not admitted during the whole of the forward stroke of a piston, it follows that the piston is not entirely thrown into equilibrium, and the crank has to assist it in the return stroke. The effect is of course equivalent to working steam expansively in an ordinary engine.

It will now be seen, and this is the most important feature of the engine, that a piston, when moving in one direction, pulls the crank, and when moving in the other, is pulled by the crank. Hence, the strain on the connecting rod is always a tensile one. No knock can therefore take place in the connecting-rod eyes on the alteration in the direction of the piston's movement; so the fit may everywhere be quite loose, and instead of constantly adjusting brasses it is only necessary to renew a few bushes when excessive wear has taken place. Similarly, the slide valve is free to slide on the crank pin, and adjust itself to its face as wear takes place, and the back of the crank disc always maintains a steam-tight joint in the same manner. The lubrication at first proved a source of difficulty, but it is now amply secured by the simple addition of an impermeator to the steam pipe, the oil being carried by the steam as a medium to all the working parts.

In the course of a series of experiments undertaken with the view of determining the point it was found that few metals would stand heavy work in high-pressure steam under such conditions. Ultimately, hard phosphor-bronze bushes for the connecting-rod eyes working on a hardened steel crank-pin, were adopted, and these are found to last a long time without any oil whatever, the steam affording of itself sufficient lubrication for these two metals. The whole machine being so well balanced, and there being, as already pointed out, no posibility of a knock taking place in any of the working parts, very high speeds are permissible for the engine; such for instance, as two thousand revolutions per minute. An average speed, however, of about 300 ft. per minute for the pistons gives a very high indicated horse power in proportion to the size and cost; besides which, there are the advantages due to the absence of dead-centre, and consequent avoidance of flywheel, involving a considerable amount of saving in weight. It will be seen that great protection is afforded to the moving parts, and that cleanliness of working is insured. The economy arising from the friction being so much reduced is very considerable, whilst the ready applicability of the engine to a great variety of uses is one of its chief merits.

By arranging the slide valve and steam connexions in a different manner the action of the steam, as already described, is reversed, and the connecting

rods are always maintained in compression. The machine then more completely resolves itself into three ordinary single-acting engines, each piston working independently of the others, but applying its force to the crank, the common property of all. This is found the more advantageous mode of working, and especially when hydraulic power is substituted for steam. Another adaptation has been successfully carried out for centrifugal sugar-drying machines which the engine is also well fitted for screw launches and for driving fans, rotary pumps, circular saws, blowers, &c., direct.

The pumping engine exhibited at Vienna, had a mean diameter of pump paddle wheel of 36 in., the inlet and outlet being each 12 in. diameter. The engine had three 9-in cylinders, the stroke being 8 in., and the steam was cut off at two-fifths stroke. The quantity delivered was 3,000 gallons per minute. The machine was perfectly silent in action, and although only standing on loose timber, was quite free from vibration.

The direct acting compound engine of Messrs. Edward Field and F. M. Cotton, of which a model was shown at Vienna by Messrs. Whitley Partners, of Leeds, is illustrated on Plate LXXV, Figs. 1 to 3. The arrangement consists essentially of a high-pressure cylinder placed within the low-pressure cylinder, and moving backwards and forwards upon a fixed piston; the annular space around this high-pressure cylinder is always filled with steam direct from the boiler, which passes into the cylinder through the ports on the lower side, the admission being regulated by the piston valves shown in the engraving. By means of these valves, also, the steam from the smaller cylinder enters the low-pressure cylinder, while at the end of each stroke a small quantity of steam passes from the annular reservoir into the low-pressure cylinder, to serve as a cushion and to move the valves. Piston valves on the top of the low-pressure cylinder, regulate the communication between it and the exhaust.

In the section, Fig. 1, A is the high-pressure cylinder, the flange and covers of which serve as a piston to the low-pressure cylinder B; the fixed piston is shown at C′, and D is the annular high-pressure steam chamber or reservoir in direct communication with the boiler by the pipe, D′, surrounding the cylinder, A, and moving with it. The piston valves belonging to this cylinder are shown at E, E′, and are connected by a spindle, I^4, I^5. They work in cylindrical passages bored out of the lugs, N, N′, and cushions, M, are introduced as shown to receive the blow from the valves, at the end of each stroke. The valves for opening and closing the exhaust of the low-pressure cylinder are shown at I, I′; they also are connected by a spindle, and cushions similar to those just mentioned are provided at I^4, I^5, for the cushioned valves, I^2 and I^3, to strike against. The exhaust opening is shown at K′. At each end of the low-pressure cylinder is formed a small groove, L and L′, which admits steam from the annular chamber into the low-pressure cylinder at the end of each stroke, for the purpose of throwing over the valves, E, E′, and of forming a cushion for the moving high-pressure cylinder. Small spindles, I, M, and M′, are provided, the former at the end of the exhaust valve chest, and the latter at each end of the low-pressure cylinder in a line with the centre of the valves E, E′, in order to move the latter if necessary.

We may now describe the action of the engine. Taking the position of the high-pressure cylinder at the end of its stroke, as shown in the section, Fig. 1, it will be seen that the valves, E E′, are thrown forward, no that steam from the annular chamber is admitted through the port, F, to the forward side of the fixed piston C; at the same time the motion of the valve, E′, has opened the exhaust port of the cylinder, A, the steam from which passes into the low-pressure cylinder. But before this takes place it is necessary to move the valves, E E′, which is effected as follows:—The cylinder, A, in coming to the end of its stroke, passes over the small grooves, L, before mentioned, and admits steam from the annular chamber, D, which passing into the small space in the low-pressure cylinder behind the end of the high-pressure cylinder, acts at once upon the back of the valve, I′, which it throws over, opening the communication between the low-pressure cylinder and the exhaust, and also upon the valves, E E′ which are moved in the position shown in the

section, Fig. 1. The steam from the chamber then passing into the cylinder, A, and that from the same cylinder being exhausted into B, both act simultaneously in the same direction.

The arrangement just described and illustrated is adapted especially for working pumps, direct, and steam is admitted into the high-pressure cylinder during the whole of its stroke. By a modification, however, the engine may be connected to a crankshaft, and any desired degree of expansion obtained in the high-pressure cylinder. The proportion between the cylinders in the engines illustrated is 5 to 1, and we may add that experiments made with a similar engine since the close of the Vienna Exhibition have given very satisfactory results, the engine running steadily at both high and low speeds, the pumping power exerted throughout, the stroke being very nearly uniform and the efficiency high.

One of the most ingeniously arranged engines in the Exhibition was that shown by Messrs. Scheller and Berchtold, of Thalweil Zurich. This engine which is constructed on Berchtold's patent is illustrated by Pls. LXI. and LXII. and by Figs. 5 and 6, Pl. LX. The general arrangement of the machine, which is exceedingly compact, will be clearly seen from the engravings. Its principal feature is that the bedplate is made to contain both air pump, hot well, and condenser, which are placed underneath the crosshead guides. The air pump, as illustrated, is double-acting, 125 millimetres (4·92 in.) diameter by 400 millimetres (15·75 in.) stroke; in the engine at Vienna, however, these dimensions were repectively 160 millimetres and 300 millimetres. The pump is worked by a somewhat complicated arrangement of levers. Convenient access can be had to the air pump valves by the two doors in the casing, the valves themselves being rectangular in shape. The arrangement of passages by which the condensers, pump chamber, and hot well are all got into a very limited space is certainly ingenious, and will be easily understood from an inspection of Figs. 8 and 9, Pl. LXII. The cylinder is bolted on to a strong flange on the end of the bedplate, and overhangs without other support. It is 300 millimeters (11·8 in.) diameter by 600 millimetres (23·62 in.) stroke, and is steam jacketted, the steam passing through the jacket on its way to the valves. The jacket and back cylinder cover are properly cleaded. The piston-rod head works in a slipper guide of large surface, and the crank shaft has its main bearing brasses adjustable both ways, the plummer block itself forming part of the bedplate. The section used in the arms of the flywheel, which will be seen in the perspective views, deserves a word of praise.

The valve gear is somewhat complicated, but we shall endeavour to make it clear by the aid of Figs. 3 to 7, Pl. LXII. It is one in which the valves are actuated from the governor spindle, and the cut off entirely under the control of the governor itself. The governor runs at the same number of revolutions as the crank shaft, and is driven by bevel gearing; it is of the ordinary type, but weighted. The valves are four in number, two steam and two exhaust. They are flat perforated discs (Figs. 5 and 7), working in a horizontal plane, and are kept tight both by the steam pressure and by small springs. The exhaust valves (under the cylinder) are worked from a grooved disc revolving on the lower end of the governor spindle by means of the arrangement shown in Fig. 4, Pl. LXII. The levers on the steam valve spindles are connected with dashpots and springs, of much the same kind as are used with Corliss valves; the way in which the difficulty of want of room for the connecting rods is got over (see Fig. 7), is very neat. All the levers are made straight-sided throughout their length, slotted behind the spindle, and the two sides nipped together by a tightening screw, Figs. 4 and 7, so that no keyways have to be cut in the spindles. The centre lines of the two dashpots are not in the same plane, but one lies about an inch higher than the other.

In the figures A is a horizontal lever working on a pin at M, and embraced by a brass slide B, on the upper surface of which are cast a couple of parallel webs enclosing a small channel L. A cam with very sharp corners (almost lozenge-shaped, in fact), revolving always with the governor spindle, and shown dotted in Fig. 7, works against the side of B, and so communicates a continual rocking motion to A in a horizontal plane. Upon the lever A itself is the fulcrum of another lever F, which can move in a vertical plane, and

which has, at the end furthest from the governor, a steel striker H, which, by pressing the piston rods of the dashpots, can open the valves. The opening motion of this striker is in the same direction (towards the crank shaft) for both the valves; in the one case it presses directly on the end of the rod, and in the other it presses on the inner side of a steel hook, the arrangement being as shown in Fig. 1, Pl. LXI. E is a block fixed to, and revolving with, the governor spindle, and having a groove in it, of which one half is at one level, and one half at another, the two being joined by steep curves, which are seen in Figs. 5 and 6, Pl. LXII. A pin in the end of the lever F works in this groove, and this lever therefore receives (in addition to the horizontal vibration given to it by A) quick motions up and down, alternating with periods of rest in each position. The limits of the up-and-down motions are so adjusted that the two corresponding positions of the striker H are exactly opposite the two centre lines of the dashpots, which, as before explained, are at different levels. D is the moveable slide of the governor, and has upon one of its faces (the one furthest from the crank shaft) an oblique straight groove, in which works a pin in the lever C. This lever can move upon a fixed pin (in a bracket K) at its upper end, but only changes its position when the upward or downward motion of the governor slide compels it to do so by giving a side motion, by means of the groove, to the pin above mentioned. The lower end of C works in the channel L on the top of the block B, previously mentioned, this channel being sufficiently long to allow C to remain in gear, whatever may be the position of the lever A. The lever F is compound, the end nearest E being separately jointed upon a vertical pin, and prevented from sharing the sideway motion given to F by A, so that it always remains in the slot in E.

The action of the gear is as follows: Suppose the striking end of H to be the level of the lower rod, and the piston to be at the commencement of its stroke. The cam on the governor spindle, pressing against the slide B, moves the lever A, and consequently also F and H, and in this way opens the valve. Directly the point of the cam leaves the slide B (as shown in Fig. 7), the spring (we mentioned before that the gear includes spring boxes and dashpots) closes the valve, and therefore presses back F and so keeps B in contact with the cam. The shape of the cam renders this closing motion practically instantaneous. During all this time the pin in the end of the lever F has been stationary in the higher half of the groove in E, as is seen in Fig. 5. On approaching the end of the stroke, however, its position is rapidly changed, and the striker is brought opposite the centre of the higher dashpot, so that when the second lobe of the cam comes in contact with B, and moves A and F' again, the valve belonging to the other end of the cylinder is opened, and so the process goes on. It will be seen that the position of B upon the lever A is determined altogether by C, and as the position of C itself is determined entirely by the governor (through the slot in D), the position of B is also controlled by the governor. As the cam on the governor spindle works against B, a little consideration will make it clear that upon the position of B upon A depends the duration of contact of the lobe of the cam, which in its turn determines the period during which the valve remains open, and by this means the cut-off is brought entirely under the control of the governor.

Figs. 5 and 6, Pl. LX., show a modification of the gear we have just described, which has also been introduced by Herr Berchtold. In this case a grooved disc revolving continuously with the governor spindle, imparts to a striking lever an oscillatory motion, alternating with periods of complete rest. The striker itself is separate from the lever, and slides in V-guides upon it. It is connected by a link with the governor sliding bush. This connexion is so arranged that the upward and downward motion of the latter moves the striker away from or towards the valve rods; its position in this direction obviously determines the time during which the striker is allowed to press against the rods; in other words, controls the cut-off. The dashpots in this case are in the same plane, but the shape of the striker head is so arranged that, while it gears with one valve rod, it simply pushes the other aside. The lead is of course constant, as in all such gears, no matter what

position in reference to the spindle the governor may give to the strikers. An engine with this gear is working at Messrs. Scheller and Berthold's shops.

Herr Berchtold's invention is almost new, only one or two engines having at the time of the Exhibition been constructed upon his patents. It is impossible to deny that it has the merit of great ingenuity, or that by it the distribution of the steam can be very exactly regulated; but it is also impossible to deny that the gear as exhibited at Vienna has fully as much complication as many Corliss gears, and on this ground may be objected to by many people. The arrangement shown in Figs. 5 and 6, Pl. LX., appears to us preferable to the other—its action may not be so precise, but this is far out-weighed by its increased simplicity. It is, indeed, a system of gear from which good results may reasonably be anticipated. In it, as in the other gear, the levers, &c., remain almost stationary except during the period of steam admission, which corresponds to a saving of power even over the Corliss valve gear. The clearance space is small, and the exhaust valves will effectually drain the cylinder. We should fear, however, that there may be some difficulty in keeping the valves tight, as there is generally in such valves a tendency to wear first at the periphery, where the motion is quickest. It is only right, however, to add that a Berchtold engine which has been at work for some time, seems to have given very good results as regards the small amount of repairs found necessary, or of wear in the gear. The suspending of the governor from the cylinder, which in its turn is entirely overhung, seems scarcely to be commended, and we fear that the extreme compactness and snugness of the condenser, &c. may be apt to interfere with its efficiency. The engine is constructed to work at from 80 to 100 lbs. pressure; and the piston rod, &c., and the whole of the valve gear, is made of steel. The cut-off is variable from 0 to ·4 of the stroke, and the number of revolutions is intended to be 60 to 66, giving a piston speed of about 250 ft. per minute.

Of all the engines in the Machinery Hall at Vienna few either attracted or deserved more attention than the one which went by the name of "the Dingler engine," and of which engravings are given on Pl. LXIII. It was exhibited by the Dingler'schen Maschinenfabrik, of Zweibrücken, and was constructed upon the system patented by their engineer, Herr L. Ehrhardt. The Dingler engine showed perhaps, taken as a whole, more points of divergence from ordinary practice than any other engine in the Exhibition; but whatever may be our opinion of the value of Herr Ehrhardt's designs, we are glad to be able to believe that they are the result of a careful study of the subject, and not of mere caprice, as unfortunately seems too often the case. In an interesting pamphlet he has published the reasons which have led him to their adoption; and as it is not often that engineers publish anything like an analysis of the reasons which lead them to choose certain forms in preference to others, and as Herr Ehrhardt's pamphlet is published only in German, we propose to give a short epitome of it, without comment of our own, before proceeding to describe the engine further.

Herr Ehrhardt assumes the advantages of high pressure steam and expansive working to be too well known to need any discussion, and goes on to point out the practical difficulties in the way of using these in a single-cylinder engine. These are:—1. The necessary heaviness of the different parts of the engine in proportion to the mean pressure in the cylinder, and the fact that the high initial pressure goes more to produce friction in the bearings than to turn the shaft; 2. Owing to the great difference between the temperatures of admission and of release, some steam is condensed on entering the cylinder only to be re-evaporated at the end of the stroke, and pass useless to the condenser, the loss by this cause being *cæteris paribus*, great in proportion to the initial pressure; 3. And chiefly, every valve and piston after being some time in use becomes leaky, so that a portion of steam flows directly and uselessly from the boiler to the condenser. The magnitude of this loss depends on (*a*) the form and condition of the valves, cylinder, and piston, and on (*b*) the difference between the pressures in the boiler and the condenser. The greater this difference the greater, *cæteris paribus*, will the loss be. This loss remains the same per unit of time whether the engine runs fast or slow, and whether it actually utilises much or little steam in

that time. An engine with high-pressure steam and large expansion will suffer a much greater loss of steam in proportion to the amount utilised than one with a lower pressure and smaller expansion. The influence of this loss on the economy of the engine is so great, that in a one-cylindered engine, running only at the usual speed, it almost wholly counteracts the advantages gained from high expansion and steam pressure. A German engineer, Herr Völkers has—after much research and experiment—arrived at formulæ in reference to this subject which Herr Ehrhardt has found in his experience to be thoroughly supported by facts. These formulæ are applied in the first of the following tables, in illustration of what has been advanced above, to two engines of the same size, but with different initial pressures and grades of expansion.

No. 2 engine must have a stronger and better boiler, and must itself be more substantial in all parts than No. 1, than which it is correspondingly more expensive, while the percentage of steam utilised is absolutely less, and the saving in fuel equivalent to the saving in steam shown in No. 13 is not sufficient to counterbalance the increased interest on capital and cost of repairs.

	Engine No. 1.	Engine No. 2.
1. Diameter of cylinder - -	15·748	15·748 in.
2. Stroke - - - - - -	39·371	39·371 „
3. Volume of cylinder - -	7625·3	7625·3 cubic inches
4. Initial steam pressure (absolute)	66·8	85·2 lb. per sq. in.
5. Cut-off - - - - - -	·25	·1 of the stroke
6. Work done by steam in cylinders per double stroke.	384,968	353,264 inch pounds*
7. Work done by steam in cylinders per minute at 30 revolutions.	28·85	26·75 Ind. H.P.
8. Steam utilised per hour - -	677·9	495·0 lb.
9. „ „ horse power per hour.	23·5	18·5 „
10. Steam lost through leakage of piston, valves, &c., per hour.	633·5	608·5 „
11. Steam lost through leakage of piston, valves, &c., per horse power per hour.	21·9	22·7 „
12. Total steam used per hour -	1311·4	1103·5 „
13. „ „ horse power per hour.	45·4	41·2 „
14. Ratio of lost to total steam -	·48	·55 „

Herr Ehrhardt's observations have led him to the following conclusions, which he claims to enunciate for the first time, viz., that in a single-cylinder engine with ordinary piston speed† the most economical results will be obtained by using steam of 90 lb. per square inch absolute pressure, and cutting off at one-eighth of the stroke. Higher pressures and grades of expansion are only advantageous in practice, with this piston speed, when the steam is expanded in two unequal cylinders, that is, in a "compound" engine. If, however, the engines compared in the above table be so strongly made, and be fitted with so efficient a valve gear, that they can work to double the assumed piston speed, a much more favourable result will be obtained, for the

* The actual mean pressure is here assumed as 75 per cent. of the theoretical absolute mean pressure due to the same cut-off and neglecting clearances.

† By this Herr Ehrhardt apparently means about 200 ft. per minute.

loss of steam per unit of time will remain the same, while the amount utilised will be doubled, as shown in the following table :

	Engine No. 1.	Engine No. 2.
15. Work done at 60 revolutions per minute.	57·70	53·50 Ind. H.P.
16. Steam utilised per hour - -	1355·8	990·0 lb.
17. „ „ horse power per hour.	23·5	18·5 „
18. Steam lost (as before) per hour.	633·5	608·5 „
19. „ „ horse power per hour.	10·95	11·35 „
20. Total steam used per hour -	1989·3	1598·5 „
21. „ „ horse power per hour.	34·4	29·8 „
22. Ratio of lost to total steam -	·31	·38 „

From this Herr Ehrhardt deduces the following law, viz., that in single-cylinder engines with expansion and condensation the real source of economy is increased piston speed. The higher the steam pressure and the grade of expansion, the higher is the piston speed which must be used that the corresponding economy may be obtained. This applies also to a certain extent to compound engines, but with the modification that, in them, for a similar economy, the speed need never be extreme. In engines with moderate pressures, &c., the necessary increase of speed will be less, and less still in non-condensing engines, although it is equally noticeable and unaccountable that many people prefer to run condensing engines at a lower speed than those without condensers ! In order, however, to obtain in ordinary working, such a degree of economy in a single cylinder engine as appears in the table above, it is necessary not only to have an engine constructed throughout with great care and exactness, but to have it fitted with some valve gear very precise in its action as, *e.g.*, the Corliss, Sulzer, or Allen gears. Higher economy than that given is only realised in new and very carefully constructed machines.

Against single cylinder machines, however perfect their construction, a compound engine (especially when used with high-pressure steam) offers the following notable advantages :—1. The whole difference between the pressures of admission and release divides itself over two pistons, one after the other, and the difference in each cylinder is, therefore, smaller than in the ordinary engine. The useful pressure on the crank and crank shaft is more uniform and more advantageously applied; and the internal friction of the machine is, therefore, less, its action more uniform, and its durability greater. 2. The differences of temperature correspond to the differences of pressure, and in consequence of the small cylinder never being in communication with the condenser, and the large cylinder never in communication with the boiler, the loss of steam by condensation upon, and re-evaporation from, the cylinder walls, is reduced by one half. 3. The two pistons and sets of valves present more obstacles to the leakage of steam than the one, and each has only to be made steam-tight against half the total difference of pressures; and moreover steam leaking through the high-pressure piston will still to a great extent be utilised in the low-pressure cylinder, and it is possible on these accounts to obtain as high a rate of economy in a compound engine with a moderate speed as with a very high speed in a single-cylinder machine.

In high-pressure engines, however, the dimensions of the cylinders are proportionately small, and the number of revolutions is, therefore, large even for a moderate piston speed, and it is very difficult to find valves and valve gear sufficiently simple, reliable, and precise which can yet work at a great speed. Herr Ehrhardt considers neither the Corliss, Sulzer, nor Allen arrangements adapted to the circumstances of the case, and has accordingly

started *de novo* to design an arrangement which shall fulfil all his requirements, the arrangement adopted being that illustrated in the plates already referred to, and which we shall now proceed to describe.

Figs. 4, 5, 8 and 9, Pl. LXIII., are sections showing the principle of Ehrhardt's construction. Figs. 6 and 10 show the construction of the valves, and Fig. 7 the construction of the pistons and cylinder covers. The general views, Figs. 1, 2, and 3 show the engine actually exhibited at Vienna, except that in the Machinery Hall the special arrangement of overhead pulleys shown in Fig. 2, not being necessary, was not adopted. Referring to the figures it will be seen that the cylinders C C are cast together and in one piece with the two valve cases and the jacket of the small cylinder. The two pistons *k* K are connected in the usual way with the crank pins, which are placed opposite each other on the solid forged double throw shaft *a a a*, which works in journals at L_1 and L_2 and has a flywheel S_1 and S_2 on each end. By this position of the cranks the moving parts are of course balanced, and the pressures on the journals at the end of each stroke are also to some extent neutralised. The steam passes direct from one cylinder to the other without any intermediate chamber. Two valves suffice to effect the whole distribution of the steam, one being placed obliquely under each end of the cylinders, as shown in Figs. 1, 2, and 3, Pl. LXIII. The valves are cone-shaped, and revolve continuously in casings, in the thickness of which are cast annular spaces *m m*, communicating both with the cylinder ports and (each through a pair of opposite openings) with the valve itself. The valves are driven by screw wheels upon a longitudinal spindle, which is itself similarly driven by the crank shaft and from which the governor also receives its motion. Figs. 8 and 9, Pl. LXIII., show the simultaneous position of the two valves, one allowing steam to enter through the jacket into the high-pressure cylinder, and to pass from the low-pressure cylinder to the condenser, while the other (at the other end) establishes communication between the two cylinders only. It will be seen from Figs. 6 and 10 that the valves are in reality double ported, and that the capacity of the ports themselves is very small. The position of the ports is such that they will drain the cylinder of water, but it appears to us that it would be advisable, at least in large engines, to have drain-cocks on the under side of the canals *m m*. The valve works free from friction caused by steam pressure, the only unbalanced pressure being in the direction of its length, as shown at *p p*, in Fig. 10, and this is taken up by an adjustable collar upon the spindle S. In order that the cut-off in the high-pressure cylinder may be under the control of the governor, each valve has on its upper end a cap having a separate spindle *s* (Fig. 10) which passes through a stuffing-box in the upper cone of the valve chest. By a simple arrangement, seen in Figs. 1 and 2, the governor can give this spindle a small angular motion, and by thus altering the position of the two openings in the valve, can control the cut off. The lead remains constant.

Herr Ehrhardt fixes an absolute initial pressure of about 150 lb. per square inch as the best for this engine, on the same grounds as those on which he thinks 90 lb. the best for a one-cylindered machine. The diameters of the cylinders are respectively 4·92 and 9·84 in., their common stroke being 19·68 in. The cut-off in the high-pressure cylinder is variable from ·05 to ·65 of its stroke, the usual cut-off being ·4, which corresponds to a tenfold expansion. The cut-off in the low-pressure cylinder is 0·9. It is worth while noticing that when the initial pressure and cut-off in the high-pressure cylinder are respectively 150 lb. absolute and ·4, the low-pressure cylinder is working almost exactly as engine No. 1 in the tables, with an initial pressure of 60 lb. absolute and a volume of steam per stroke equivalent to a cut-off of ·25 at the full initial pressure. To convert a pound of water into steam of 150 lb. pressure, only requires about $\frac{1}{59}$th more heat than to convert it into steam of 60 lb., so that practically nearly the whole work done in the high-pressure cylinder is obtained, beyond that shown in the tables for the one-cylindered engine, without extra fuel beyond that required to make good the extra losses by condensation and radiation at the higher pressure.

We have not now space to say much as to the general arrangement of the engine, which is clearly shown in Figs. 1, 2 and 3, Pl. LXIII. We need only

mention a few points. The steam cylinders and valve chests are cleaded all over, and entirely covered in in a way which makes the engine look, at first sight, as if it had only one cylinder. The bedplate is very simple in construction, and has in most places hollow and rectangular sections. The piston rod heads work between faces bored out in the framing. The main bearings are adjustable both ways. Pins are cast inside the flywheels by which (through a hand lever seen in elevation and plan) the engine can be turned by hand. The air pump is worked by an eccentric, and is, with the condenser, entirely separate from the main casting; the exhaust steam passes through a feed heater under the cylinder before reaching the condenser. The engine can be worked either with or without the condenser, at pleasure.

We need allude only to one point more, namely the construction of the piston, as shown in Fig. 7, Pl. LXIII. Herr Ehrhardt gives his reasons for using it as follows: he considers that after a short period of working the cylinder gets smoothly polished, and the piston ring so much worn that it no longer acts as a spring, the piston being thus, during the greater part of the engine's duration, not absolutely tight, but, as it were swimming in steam and oil, and always passing a certain amount of steam. This he takes to be so sure a fact that he thinks it best to assume at once that some loss is necessary, and only to try to prevent its being too great, and at the same time to remember that it is this steam which prevents both cylinder and piston being rapidly worn out.

On this ground the piston of the Dingler engine is made, as shown, entirely without springs or tightening apparatus of any kind, in the belief that, once made to fit the cylinder well, it will remain just as long tight without as with a spring. As the piston, however, expands more than the cylinder, and would thus injure it if it were tight at first and at the same time of an unyielding construction, it is made of the light and unrigid form shown, for which also the advantage is claimed that, there being always steam pressure inside one of its two ends, that end can spring enough to be kept in sufficiently close contact with the cylinder walls. The leading idea in the design of the piston is that the necessity of some loss of steam being recognised, this loss should be made as small as possible, and at the same time used to increase the durability of the cylinder. Herr Ehrhardt considers, also, that exactly the same remarks apply to the working of the valves as to the piston, and expects them to remain equally free from wear.

We regret that our space does not permit us to do more than state Herr Ehrhardt's views without discussion. We should add that the engine at Vienna ran at 115 revolutions per minute, and seemed almost, if not absolutely, noiseless. A similar one at the maker's works at Zweibrücken is said by them to show no wear of any importance, although it has now been at work over two years.

Two of the engines in the Austrian department have to be mentioned here. The more important was exhibited by the Prager Maschinenbau Actien Gesellschaft (formerly Ruston and Co.), Prague, and had Dautzenberg's patent valves and valve gear. It is a large horizontal condensing engine, with a cylinder 16·59 in. in diameter by 37·33 in. stroke (16 in. by 36 in. Austrian measurement). There are two outlet and two inlet valves, all of them being slides, and the steam valves are balanced, but the mode in which they are worked cannot well be made intelligible without the aid of drawings. The special feature about them is that the closing of the steam valves is effected by the actual pressure of the steam itself, instead of by a spring, when the governor severs the connexion with the eccentric. The air pump is worked underneath the engine by an arrangement of levers. Several of the details about this engine were very good—as *e.g.* the connecting rod head—and its general workmanship was also to be commended.

The other engine in the Austrian section belonging to this class was one shown by the Maschinen und Waggons Fabriks Actien Gesellschaft, in Simmering, late H. D. Schmidt, and was fitted with valves and valve gear arranged upon a system invented by Professor Radinger, of Vienna. Like the other engines exhibited by the same makers, this, which is illustrated on Pl. LXIV., is substantial in design, and thoroughly well made; like them also

it stood motionless in the Machinery Hall, and we had, therefore, no opportunity of seeing how the arrangement of valves worked. We understand that the engine exhibited was the second only which had been constructed upon the system.

About the engine itself we need not say much. The bed-plate is carried along underneath the piston and connecting rods; the guide plate and the plummer block are cast with it. The cylinder is attached to it in a way similar to that in which the cylinder of the 4 horse power engine by the same makers, which we have already described,* was attached; but in this case it is not overhung, but is supported by a substantial foot, which is made separate, we presume, on account of the complexity of the cylinder casting.

The valves are three in number, and are arranged on three parallel vertical spindles, the whole of them deriving a continuous revolving motion from a horizontal shaft driven from the crank shaft by spur gearing, the proportions of which are so arranged that all the valves have the same angular velocity as the crank shaft, that is, that they rotate revolution for revolution with the engine. The centre valve is double, consisting of two cones, revolving one within the other, in opposite directions. The outer cone governs the steam admission, and may, therefore, be called the induction valve; the inner cone governs the cut-off, and may be called the expansion valve. The governor is so arranged, as will shortly be seen, that the motion of the balls alters the relative positions of these two valves, and by this means alters the cut-off in a way analogous to that in which it is altered by the common right and left-handed screw arrangement for flat valves. The other valves are in shape not unlike the exhaust valves of a Corliss engine—that is to say, they fill up more than half the chamber in which they rotate; each one governs the exhaust from one end of the cylinder. Fig. 3, Pl. LXIV., shows the relative position of the valves in plan, and the manner in which the ports are arranged.

The bevel pinion on the end of the horizontal spindle gives motion in opposite directions (see Figs. 3 and 4) to two bevel wheels. The upper wheel is fast to a bush, which forms the lower end of the induction valve. The lower wheel is keyed on to a spindle, which passes right up through the valves, perfectly unattached to anything, until at the top it forms the spindle of the governor. There is a slot in the governor spindle, near its upper end, and a cross piece, which is connected at each end to the pins in the sliding bush of the governor, passes through this slot. Between the governor spindle and the sliding bush there is another bush, which, being carried downwards (in several pieces), is rigidly connected with the expansion valve. This intermediate bush has a slot on each side, through which the cross piece above referred to passes; these slots are placed spirally, however, at a small angle to the vertical. The expansion valve is driven by the pressure of the cross piece against the sides of these slots, and, therefore, its rotation corresponds exactly with that of the governor spindle. When, however, the governor balls move out or in, the cross-piece is raised or lowered, and in consequence of the oblique slots just mentioned, the expansion valve receives a small angular motion relatively to the governor spindle. We know that the angular motion of the induction valve is equal and opposite to that of the spindle, and, therefore, it is obvious that as long as the expansion valve moves exactly with the spindle, the cut-off must always take place at the same time. But by the action of the governor just described, the relative positions of the expansion valve and the spindle can be altered, and consequently the precise point in the revolution of the induction valve at which the edge of its opening passes the edge of the expansion valve; in other words, the precise point at which the cut-off takes place is altered also, thus leaving the cut-off entirely under the control of the governor. The governor itself is of the ordinary type; it is connected with an index (Figs. 1 and 4, Pl. LXIV.), which shows, at any moment, the degree of expansion at which the engine is working. The two exhaust valves are driven by spur gearing from a wheel fixed upon the bush of the induction valve. Upon the top

* See page 17, *ante*.

cover of the centre valve chest, which is made in halves, is cast a bracket, which supports an elaborately constructed nut, by means of which the induction and expansion valves can be adjusted vertically relatively to each other, and relatively to the seat in which the former works; in this way it is intended that the wear should be taken up. The lower end of the governor spindle is carried in an adjustable socket bearing, so that whenever the wear on the valves renders it necessary to bring them down a little, the governor spindle may be lowered too, otherwise the action of the governor would be rendered less perfect.

Professor Radinger's system of valves and valve gear is certainly ingenious; it is quite correct in theory, and has been very carefully worked out. By means of it the engine will have a constant lead, an expansion accurately controlled by the governor, a very quick cut-off, and points of release and compression entirely independent of lead or cut-off—all of them matters of considerable importance. It cannot be denied, however, that the apparatus by which these advantages are gained is complicated and expensive, will require careful attention, and is awkward to take to pieces. On these accounts we are afraid it will not come into general use, certainly not for engines so small as that now under notice, where even if a large percentage of saving in fuel is possible, the money value of this saving is still insignificant.

The engine we have been describing is well made and beautifully finished, though without superfluous polishing. The cylinder is 265 millimetres (10·43 in.) diameter, and 630 millimetres (24·8 in.). The ordinary cut-off is ·33 of the stroke, variable from ·1 to ·6 by the governor. The working steam pressure is intended to be 60 lb. per square inch, and the revolutions 65 per minute.

Two other engines remain to be noticed here, both having been exhibited in the Russian section, one was shown by Baranowsky, of St. Petersburg, and was a small horizontal compound engine with the high-pressure cylinder placed on the back of the low-pressure one. One small valve, most inconveniently placed, regulates the whole distribution of the steam, and the governor (which is very like a Pickering governor, but is placed on the crank shaft) is connected with a very diminutive valve of peculiar construction in the steam pipe. A small vertical boiler, with vertical tubes, which is intended to supply steam for this engine, was also exhibited.

The last engine we have to notice in the present class is a small compound engine by Bertrand and Scharr, of Odessa. It has cylinders 150 mm. and 200 mm. (5·9 in. and 7·87 in.) diameter by 300 mm. (11·81 in.) stroke, and the peculiarity of it is that by a very simple arrangement, either cylinder can be worked alone, both with fresh steam, or one after the other in the usual way. The valves are of the ordinary description (no expansion valves), and the cranks are set at 90°.

Winding Engines.

The winding engines, of which four came from Austria, one from Germany, and one from France, mostly showed a high class of work, although some were scarcely as substantial as we are accustomed to make such engines. Messrs. L. A. Quilliac and Cie, Anzin (Nord), France, had a pair of long-stroke engines with drums for flat wire rope. They were very highly finished—indeed their workmanship was exceptionally fine. The brake wheel is separate from the drums, and keyed on to the shaft between them. There is a double brake which can be applied either by hand, screw gear, or by steam. The rims of the drums are of wood, and the arms from the rims outwards are also of wood, but finished off with iron rings formed of plates bent into something the shape of an angle iron. The valves are ordinary slides with expansion valves on the back, and the engines are fitted with link reversing gear. The valve gear, however, is of the most extraordinary description; the designer of it must surely have been desirous of seeing how many rods, levers, links, and fulcra (movable as well as fixed) he could use to obtain a very simple motion, instead of how few.

The Wilhelmshütte Actien Gesellschaft für Maschinenbau und Eisengiesserei, of Sprottau, Silesia, showed the only pair of winding engines exhibited

in the German section of the Machinery Hall. It has a pair of cylinders, each 22·63 in. diameter by 49·4 in. stroke, and was sold as 80-horse power nominal. Its general design is clearly shown by the views on Pl. LXV.; it was well made, and was rather marked by an absence of the overhanging parts in the gear, which characterised too many of the engines near it. The valves are shown separately in Figs. 3 and 4. It will be seen that they are of the ordinary double-beat type, and that distinct valves are provided for the induction and eduction. The ports are arranged so as to drain the cylinders of water. One eccentric suffices to work each set of valves; its rod is connected with the lower end of a straight vibrating link, and the engines are linked up, or reversed, by moving the valve connecting rod in the link, instead of the link on the rod. The valve connecting rod works a couple of short rocking shafts placed across the top of the valve chest, and tappets upon these shafts are arranged to raise the valve levers at the proper time. The valves are closed by weights placed on the upper ends of their spindles.

The winding drums are built of wrought-iron framework upon cast-iron centres. The pair of centres for one drum are keyed upon the shaft, and on the inner side of this drum the brake disc is bolted. The other drum is, as usual, driven indirectly, in order that it may be disconnected when the length of the rope is being adjusted. The following is the method employed for driving it: Two toothed wheels are keyed to the shaft, and always driven by it. These wheels have turned projecting bosses upon which fit the centres of the drum. Two cast-iron cross pieces, having teeth upon them corresponding to the teeth of the spur wheels, are placed within the framing of the drum, and so arranged that they can be moved radially either into or out of gear with the spur wheels. When they are in gear, the whole drum is driven through them, the centres revolving with the spur wheels, but when they are out of gear, the drum itself can be kept stationary while the engine drives the other drum alone, so as to lengthen or shorten the free length of rope as may be required. The drums are made conical so as to balance the rope in the pit; round wire rope is of course used. The brake, as in all the other winding engines shown at Vienna, is made so that it can be applied either by steam or hand.

In the pavilion of the Maschinenbau Actien Gesellschaft (formerly Danek and Co.), Prague, were two pairs of winding engines. The large pair has cylinders 19 in. in diameter by 6 ft. 4 in. stroke. It works with flat wire rope, and is intended for depths up to 150 fathoms, and, like the above-mentioned engines, it has a brake to work by steam or hand. The brake wheel is on the centre of the shaft, between the drums. The cylinders have ordinary slide valves, the expansion being entirely managed with the reversing link, by linking up. The arms of the drums are of channel iron, which is both neat and strong, the side spaces between the arms are fitted up with wood; in the other engines they are all left open. Messrs. Danek's other winding engine is a smaller one, and is intended only for shallow pits. Its cylinders are 9½ in. in diameter by 18 in. stroke, and they are geared to the drums (which are 7 ft. in diameter, and are intended for round wire rope) in the proportion of about 1 to 4. The outside leg of each bedplate is carried forward to the centre of the drum shaft, and has the bearing block cast in it. This engine (of which further particulars will be found in the section of these reports dealing with cranes and hoisting machinery) has only a hand brake.

The Prager Maschinenbau Actien Gesellschaft (formerly Ruston and Co.), Prague, showed a large pair of winding engines, with cylinders 19·7 in. in diameter by 74·6 in. stroke (19 in. by 6 ft. in Austrian measurement). They are intended to develop 200 effective horse power, and to work pits from 200 to 300 fathoms deep. The drums are for flat wire rope, they are 8 ft. in diameter on drum, and 14 ft. in diameter at extremities of arms. The valve gear is on a patent system belonging to the firm. Bevel gearing on the main shaft drives a spindle lying along the centre of the engine between the cylinders. A long movable steel sleeve on this spindle forms in effect a series of cams from which the valves (which are very much the same as in the Wilhelmshütte engine) are worked, the expansion being thus automati-

cally variable. The position of this sleeve determines the distribution of steam as well as the direction in which the engines revolve. The brake in this engine and the next can be worked either by steam or hand. The only other winding engine was exhibited by the Fürst Salm'sche Maschinenfabrik in Blansko, and is of somewhat smaller size than Ruston's, and intended for round steel rope instead of flat. The framing of the drums is of iron, but the drums themselves are of wood, and are 13 ft. in diameter by 34 in. wide. The cylinders are 22 in. in diameter by 5 ft. stroke. The crank pins are made ball-shaped to allow for the shaft not running true, and the crank shaft bearings are made to adjust both ways. The valves are slides, with a unique arrangement of inner slide between the valve and the cylinder face, by shifting which the engines are reversed.

The whole of these engines have alarm bells and apparatus for ringing them in time to prevent overwinding, these arrangements being, in some cases, very neat and ingenious. In most instances they have also an automatic connexion with the steam brake. All the engines have also some arrangement by which one drum can be disengaged from the shaft and kept steady, while the other is being driven round, the object of this being to adjust the length of the rope.

Pumping Engines.

In the section of these reports, dealing with the arrangement of the Vienna Exhibition, we have explained the provisions made for furnishing an efficient water supply, and have mentioned that there were altogether three pumping stations, namely, one near the western end of the Machinery Hall, one near the eastern end of that building, and one near the main entrance to the Exhibition. It is of the engines at these pumping stations that we have now to speak, and we propose to do so in the order in which we have mentioned them.

The pumping engine house near the western end of the Machinery Hall, contained a fine pair of engines, by the Erste Brunner Maschinen-fabriks Gesellschaft, of Brünn, and of one of these engines, a side elevation and plan is given on Pl. LXVI., while views on Pl. LXVII., Figs. 1 and 2, show the arrangement of the pair of engines with their boilers. The water tower, to the height of which the engines raised the water, was described by us when treating of the buildings, and it is illustrated in Pls. XXII. and XXIII.

The water was drawn by the engines of which we are now speaking from about 18 ft. 6 in. below the level of the pumps, and delivered into a reservoir on the top of the water tower, 155 ft. 6 in. (150 ft. Austrian) above them. The water pressure was thus nearly 70 lb. per square inch, and the steam pressure used was the same. The engines have cylinders 19·7 in. diameter by 43·55 in. stroke, and the pumps are 11·9 in. diameter. Either engine can be worked by itself or the two together, at pleasure, and the quantity of water delivered varies from 6,000 to 10,000 cubic feet (37,500 to 62,500 gallons) per hour.

The engines are of the Corliss type, very similar in construction to the engine exhibited by the Erste Brünner Company in the Machinery Hall. The gear is similar in design to that of Herr Reinecke's, already described by us, and illustrated on Pl. LVI. The eccentric works an irregularly shaped disc, which gives motion to the two exhaust valves, and also to the two long levers placed on the side of the disc next the crank shaft. Catches working on pins in the tops of these levers open the steam valves by pressing against the ends of the spindles when the levers are pulled forward. The catches have curved ends behind, and when these come into contact with the fixed stops above them they are depressed, the catches raised above the spindles, and a strong plate spring on the back of the lever pulls the spindle immediately back, and consequently closes the valve. Under ordinary circumstances the position of the stops is regulated by the governor; but as in a pumping engine there is no governor (the resistances being always the same, while the speed must be variable at pleasure), their position is regulated by hand by means of a hand wheel through the simple arrangement of gear shown. At Vienna, a float in the reservoir, by an electrical arrange-

ment, was made to indicate, in the engine-room, the water-level in the tank, and on the column below the hand wheel just referred to was an index which showed not only the grade of expansion, but the number of turns the engine was making (or ought to make) per minute, and the quantity of water it was delivering, so that the man in charge knew exactly what his engine was doing, and what was the state of the water in the tank. Between the two cylinders, and underground, lies a cylindrical tubular feed heater, through which the exhaust steam passes.

The pumps form castings entirely separate from the engines, to which they are only connected by wrought-iron stays. They are double-acting, and have two suction and two delivery valves at each end. The valves themselves are of india-rubber, and have wrought-iron back plates held down by spiral springs. The bushes sliding on the centre pins are of brass, and the valve gratings are cast iron. The delivery pipes are 10·7 in. diameter. A wrought iron wind-chest, which is divided into parts by a cross diaphragm, serves as an air vessel both for the suction and the delivery, as will be seen from the engravings, and in addition to this there is the usual cast-iron air vessel just above the delivery valves.

The two boilers (of which one was found sufficient to supply both engines with steam in ordinary work) are upon Dupuis' patent. Each consists of a long horizontal cylinder communicating at the back with a shorter vertical one considerably larger in diameter, this latter containing 96 tubes running from top to bottom. The furnace is under the front of the horizontal cylinder, and the products of combustion pass round the vertical cylinder, and down underneath it, and then upwards through the tubes and into the flue, as shown the plan. The steam is taken away from the top of the vertical cylinders. The engines, pumps, and boilers, seemed well and substantially made throughout.

The engines in the pumping station at the eastern end of the Machinery Hall were supplied by a French maker, E. Prunier, of Lyons, and one of them is illustrated on Pl. LXVII. The two engines which the station contained were placed side by side, and as they were exactly similar in size and construction, we shall in our description for convenience sake speak only of one.

The well was sunk directly below the pump, it was simply a cast iron tube 1 metre in diameter, sunk about 17 metres (55 ft. 9 in.) into the ground in order to reach the water-bearing strata. The sinking of the well was conducted on a system invented, we understand, by M. Prunier, and used for the first time at Vienna, by means of endless bucket chains (like those of a dredger) worked by four men, and so arranged that the whole apparatus, suitably guided, sank vertically into the soil as the gravel was removed from the interior of the tube. The water was delivered into a large tank placed about 14 metres (46 ft.) above the level of the ground, at the rate of 400 to 600 cubic metres, or about 88,000 to 132,000 gallons per hour.

The pump is placed directly over the well, the cylinder over the pump, and the crankshaft with a flywheel on each end, over the cylinder. At the level of the upper cylinder cover is a platform, to which access can be had by a stair, which allows the crosshead, connecting rods, &c., to be conveniently got at. The chief peculiarity of the apparatus is the construction of the pump itself. It has two plungers, of which the lower one is attached to a continuation of the piston rod (and, therefore, moves always the same way as the steam piston), while the upper one is fixed upon a tube sliding freely upon the rod just mentioned, and fixed at its upper end to a substantial crosshead. This crosshead works in guides placed between the pump cover and the lower end of the cylinder, and receives its motion (through a pair of connecting rods), from crank pins placed upon the outside of the flywheels opposite to the main crank of the engine. It is obvious, therefore, that the two pump buckets move always in opposite directions, either towards or from each other. When moving towards each other the lower bucket lifts water, which passes freely through the upper one, when moving away from each other the upper one lifts the water, while the lower passes down through it. Each bucket is fitted with three india-rubber conical rings, covering orifices in the metal cone below, and these serve as valves, opening during

the descent, and closing during the ascent of the buckets. The diameter of the pump is 400 millimetres (15·74 in.), and the stroke of each bucket is 600 millimetres (23·62 in.); the capacity of the pump is, therefore, equal to that of a double-acting pump of the same diameter and stroke, or a single-acting one of the same diameter, and 47·24 in. stroke. The work done by the steam upon the two sides of the piston is as nearly as possible the same.

The steam cylinder is 600 millimetres (23·62 in.) diameter, and the same in stroke. It is fitted with two plain slide valves, one for each end. These are arranged to cut off the steam at one fifth of the stroke, but M. Prunier prefers to use a higher pressure than was allowed at Vienna, and cut off the steam at one-twelfth. Each valve is worked by a separate steel cam upon the shaft, between the crank-web and the bearing, the cams being made of such a shape as to open and close the valve quickly. An annular space below the cylinder is used as a condenser, and two single-acting pumps worked from the crosshead serve as air pumps. A worse place for the condenser, however, can hardly be imagined, for besides that it necessitates an awkward arrangement of air pump valves and connexions, the facilities which it affords to the passage of heat from the cylinder to the condenser, to the injury of the efficiency of both, are very apparent. It would certainly be better to carry the exhaust steam down through a pipe, and arrange the condenser in or about the delivery chamber of the pump.

The principal advantages claimed by M. Prunier for his arrangement of pump are, that the water is always carried in the same direction, that there is therefore a total absence of shock, and that the working rods are always in tension, never in compression; the arrangement is, however, complicated, and one which we cannot regard with favour. The pumps shown in the illustration could make from 15 to 50 strokes per minute, according to circumstances. At the latter speed the two pumps together would deliver about 500 cubic feet per minute.

The last pumping engines of which we have to speak here are those at the pumping station near the main entrance, these engines having been constructed by the firm of Gebrüder Decker, of Canstatt (Würtemburg), and being employed at Vienna in supplying water for the eight fountains in the Exhibition grounds, as well as for watering the gardens. They are illustrated in Pl. LXVIII.

In Figs. 1, 2, and 3 of the plate just referred to, A A are the steam, and B B the pumping cylinders, and C C the connecting frames. D D are the valve chests, and F F the arms for moving the valves by striking the buffers G G. The cylindrical wrought-iron chamber placed between the pumps is divided into two parts by a diaphram O; the lower part of it H serves as an air vessel for the suction, and the upper part J for the delivery of both pumps. M and K are the suction pipes, and L and N the deliveries, The construction and working of the machines is extremely simple. On coming near the end of its stroke, the arm F strikes one of the buffers, and shifts the valve (a piston valve) into its mid position, so as to close both the ports and cushion the piston. A portion of the steam which has just done its work is then admitted to the valve and completes its stroke so as to make the piston move in the opposite direction, the same operation being repeated at each end of each stroke. A socket is provided at P, in which a lever for starting the valve by hand can be inserted.

The pumps are fitted with a very simple condensing apparatus (patented by Decker Brothers), which must be a source of considerable economy, but which is intended primarily to obviate the expense and inconvenience of long exhaust pipes, when the pump is used in mines, or other such situations. It consists merely of a box Q placed in the line of the suction pipe M, and communicating with it by a number of ring openings bevelled forward in the direction of the water's motion. The steam is admitted through the cock R (which is so arranged as to discharge it direct into the atmosphere when required) into an annular space in Q, from which it is drawn into the suction through the openings mentioned above. We understand that this arrangement has given much satisfaction where it has been used.

The small cylindrical vessel S is for the purpose of replenishing the delivery air vessel with air, and is used as follows: it is first allowed to fill with air by opening the two cocks freely to the atmosphere. By turning these communication is then established (through the pipes seen in Fig. 2) between it and the two ends of the vessel, and the water from the lower part of the latter will then displace the air in S, transferring it to the upper part of J. The cocks are then again opened to the atmosphere (and so closed to J), the water in S allowed to run out, and the process repeated as often as may be necessary. Fig. 4 shows the arrangement of the pump and valves to a larger scale. The valves themselves are of leather, stiffened with wrought-iron plates. The steam and water cylinders are the same size, namely, 15·748 in. diameter and 37 in. stroke. They are together capable of delivering 500 to 600 cubic metres (about 110,000 to 132,000 gallons) of water per hour. They are very much stronger than was necessary for the light work they were doing at Vienna, as they were intended for subsequent use for draining mines, with a water pressure up to 225 lb. per square inch. In this case they would be fitted with additional larger steam cylinders, so that each pump would be virtually a compound engine. At Vienna they worked with a steam pressure of 55 lb. to 60 lb., a water pressure of about 40 lb., and at the rate of ten double strokes per minute (less than half their maximum speed). They were supplied with steam by Tedesco's boilers, which we have described in the proper section.

These pumps worked well although during part of the time they were rather noisy, and they certainly have the advantage of great simplicity in construction, and of wasting no power in driving shafting, &c., as well as of being cheap and compact. At the same time, however, as they cannot be worked expansively, they can scarcely attain any economy in fuel compared with fast running and expansively working engines. We should have mentioned that Messrs. Decker Brothers are the sole Continential licensees for Earle's patent, under which these pumps are manufactured.

The small steam pumps and donkey pumps exhibited at Vienna, we shall describe hereafter in sub-section devoted to them.

Blowing Engines.

Undoubtedly the most important exhibit in this class at Vienna was the large blowing engine—constructed by the Société John Cockerill, of Seraing—which formed such a conspicuous object in the Belgian section of the Machinery Hall. This engine, which is illustrated on Pl. LXIX., is of a type which the Société Cockerill commenced building in 1853, the arrangement having been designed at that time by M. Brialmont, then the engineer-in-chief to the firm, for an engine constructed for the Usines de l' Espérance, at Seraing. The engine then built had a blowing cylinder 3 ft. $6\frac{5}{8}$ in. in diameter by 7 ft. $4\frac{3}{8}$ in. stroke, and it was of sufficient size to supply blast to one furnace, the speed being not less than ten strokes per minute.

At the time this first engine of the general type we illustrate was built, much attention was not paid to economy of fuel at iron works, and blowing engines were rarely fitted with condensers or arranged to work with any considerable degree of expansion. Now this is to a great extent changed, in Belgium at all events, and the Société Cockerill have for some little time past constructed all the blowing engines built by them on the compound system, and of course with condensation, the engine which was exhibited at Vienna being thus arranged. Since they first commenced building these vertical blowing engines also, they have gone on gradually increasing the sizes of the blowing cylinders from 1·83 metres to 2·13, 2·5, 2·64, and finally to 3 metres or 118·11 in., this latter dimension being the diameter of the blowing cylinder of the engine we illustrate. The stroke is 2·44 metres, or 7 ft. $4\frac{3}{8}$ in.

Referring to Pl. LXIX., it will be seen that the frame of this engine is formed of four cylindrical cast-iron columns, which spring from the base plate, and inclining inwards, are firmly secured at their upper ends to the bottom cover of the blowing cylinder, this cover forming a kind of entablature. At about two-fifths of their height these columns are connected in both directions by

cast-iron girders carrying a platform. To the inner sides of the columns are fixed the guides for the crosshead, whilst one pair of the columns also carries brackets for the support of the centres on which the back levers for working the air pump oscillate. This arrangement of framing has the advantage of reducing the weight of the largest pieces to be transported, and Messrs. Cockerill speak highly of its stability; but we ourselves prefer the form of framing generally adopted for vertical blowing engines in this country in the Cleveland district and elsewhere, as being more rigid and less likely to be affected by any defect in the foundation. It is only fair to say, however, that the engine when running at the Vienna Exhibition showed no signs of want of stiffness in the framing.

The two steam cylinders are respectively 28·74 in. and 41·73 in. in diameter, and they are placed side by side at a sufficient height above the bedplate to allow of the flywheel shaft being carried beneath them. The manner in which they are supported is shown by Pl. LXIX., from which it will be seen that they are carried by six short conical columns, these columns being traversed by bolts extending down through the foundation. The cylinders are thus tied down directly to the latter. The two piston rods extend upwards to a massive wrought-iron crosshead to the centre of which the piston rod of the blowing cylinder is attached, as shown. The steam cylinders, it will be noticed, are so arranged that the points of attachment of these rods to the crosshead are at distances from the centre inversely proportionate to the diameters (not the areas) of the cylinders, the object being to insure as far as possible that the resultant of the pressure due to the action of the steam in ordinary working should be transmitted direct to the rod of the blowing cylinder without throwing a cross strain upon the crosshead. The piston rods, it will be seen, are connected to pins which traverse the crosshead at right angles to its length, and thus any tendency to movement due to inequality in the length of the connecting rods has to be resisted by the crosshead guides, and does not throw a bending strain upon the piston rods. From the ends of the crosshead, connecting rods extend downwards to crank pins in a pair of overhung flywheels 26 ft. 3 in. in diameter and weighing about 16 tons. These flywheels are constructed so as to counterbalance the engine, and the latter can be handled freely in any position.

Between one of the flywheels and its adjacent bearing the flywheel shaft carries a spur wheel which, through the intervention of an intermediate, or idle, wheel drives the shaft carrying the cams for actuating the steam distribution valves. These valves are of the Cornish equilibrium pattern, and are six in number, namely, two admission valves for the small cylinder, two valves for admitting the steam from the small to the large cylinder, and two exhaust valves for the large cylinder. In a still more recent arrangement designed by M. Kraft, the present chief engineer to the Société John Cockerill, eight valves are employed, and a reheater—heated by steam taken direct from the boiler—is arranged between the two cylinders for superheating the steam on its way from one to the other. The air pump and condenser are arranged in a tank at the back of the engine, as shown in the engravings, the air pump, and also the feed and other pumps, being worked from levers connected to the crosshead as shown.

The blowing cylinder piston is fitted with metallic packing, and the valves —both inlet and outlet—have a very large area so as to avoid shocks. In the engine shown at the Exhibition the upper and lower outlet nozzles of the blowing cylinder were united by a wrought-iron casing, having a single opening from which the blast main is to be led off. Working with a pressure of steam of four atmospheres effective, or, say, 60 lb. per square inch, and with a total expansion of $5\frac{1}{2}$ to 1, the engine supplies blast at a pressure of 20 centimetres of mercury, or 4·86 lb. per square inch, and makes $12\frac{1}{2}$ revolutions per minute; the effective work done under these circumstances being about 230 horse power. The engine we have described is a very good piece of workmanship, and it is the 103rd engine of its type constructed by the Société Cockerill. The makers had also on order and in progress at their works during the period of the Exhibition twenty-five similar engines, some of them being even larger than that shown at Vienna.

The exhibit of which we have next to speak is a pair of horizontal blowing engines constructed and exhibited at Vienna by the Maschinen und Waggon Fabriks Actien Gesellchaft in Simmering (late H. D. Schmidt). Its general design is very simple, and will be easily understood from the views given on Pl. LXX. Each blowing cylinder is worked direct from the prolongation of the piston rod of a steam cylinder, the coupling connecting the two rods being formed so as to make a guiding head. The front end of the piston rod of each blowing cylinder also works in guides, and drives a crank by means of a light connecting rod. The two cranks are set at right angles, and the flywheel is placed between them on the centre of the crank shaft. Each steam cylinder is fitted with a close-ended slide valve and expansion plates working upon its back. The expansion plates are fitted with right and left-handed screws, and gear is provided by which the cut-off can be altered by hand while the engine is running. Each blowing cylinder has four suction and four discharge valves upon each end; these are seen in Fig. 4, the upper and lower pairs of valves being the suction valves, and the side pairs the discharge valves. The valve gratings are all horizontal, and the valves themselves are flaps of very much the usual construction. Discharge passages are cast along the sides of each cylinder and join in a belt underneath it, from which they communicate with the main pipe through a plain disc valve. The main framing of the machine is in three castings—one supports each pair of cylinders, and the third carries the plummer blocks and passes round, in horseshoe shape, in front of the flywheel.

The following are the principal dimensions of this blowing engine:—

	mm.	ft.	in.
Diameter of steam cylinders	400	1	3·75
Do. blowing do	850	2	9·46
Stroke	950	3	1·4
Diameter of wind pipe	280	0	11
Number of revolutions per minute	50		
	cb. m.	cb. ft.	
Wind discharged per minute	80	2824	
	mm.	in.	
Pressure of wind (mercury)	80	3·149	
Do. (lb. per sq. in)	1·536		

Combined Engines and Boilers, or Semi-fixed Engines.

Small engines combined with boilers, were very plentiful at the Vienna Exhibition. They were of every possible shape and construction; in some the engine was rigidly bolted to the boiler throughout; in some entirely detached from it; some had feed heaters and expansion valves, and some disdained such appliances entirely; there were vertical boilers and horizontal boilers, boilers with direct tubes and boilers with return tubes, boilers carefully cleaded and boilers carefully uncleaded; and, it must be added, there was good workmanship, moderate workmanship, and very bad workmanship, and for every one of these peculiarities (except the last) the exhibitor had an excellent reason, and each exhibitor seemed prepared to maintain that, taken altogether, his own particular design and construction was the best in the Exhibition. As all these engines were in one or other of the machinery halls, it was of course impossible to set them to work; there were, therefore, no means of comparing their actual working with the somewhat "high-falutin" prospectuses by which some of them were accompanied, but a fair estimate of their capabilities could nevertheless be formed.

All the English semi-portables were to be found in the Western Agricultural Hall, and as a whole they did us credit. They were all exhibited by firms well known in the agricultural machinery trade. Messrs. Ruston, Proctor, & Co. showed a very neatly arranged 3 horse-power engine with jacketted cylinder 6¼ in. in diameter by 10 in. stroke. The engine is vertical, the cylinder being bolted direct to the boiler at the top and the bearing brackets at the bottom. The boiler is an ordinary vertical, with two cross tubes 6 in.

in diameter in the firebox, the feed water is heated by a small blower pipe from the exhaust. In common with most of the English makers Messrs. Ruston, Proctor, & Co. try, by cleading the boiler, to prevent radiation of heat; but strange as it may appear, scarcely any of the continental makers have adopted this, the simplest of all measures of economy.

Mr. W. N. Nicholson (Newark) has evidently quite different ideas from Messrs. Ruston, Proctor, & Co. as to what a combined engine ought to be. He exhibited four such machines of 1, 2, 3, and 4 horse power respectively. He has ordinary vertical boilers with cross tubes in the firebox, but he makes the engine quite distinct from the boiler, placing the two on the same bedplate, which (being divided into two parts) serves as an ash pit for the one and a water reservoir for the other. The cylinder is cast in one piece with two columns, which form the supports for the plummer blocks, and to which the guide bars are attached. The two covers for the blocks are cast in one, being joined together by an arch, which must help a good deal to steady the engine.

Messrs. Marshall, Sons & Co., Limited, exhibited a 7 horse-power double cylinder engine on a locomotive boiler and fitted with link motion. It was well and substantially made. The cylinders on the usual pattern, are steam jacketted, and the piston rods, slide rods, valve gear, &c., are all of steel. It is an engine evidently intended to stand wear and tear.

Messrs. Davey, Paxman, & Co., showed an 8 horse power combined engine with their now well-known patent boiler. The principal heating surface is obtained in this boiler by the employment of water tubes, which spring from the sides of the firebox, and extend upwards to the crown, as shown in the vertical and horizontal sections on Pl. LXXI., Figs. 1 and 4. Tubes so disposed have been employed in other boilers; but the distinguishing features of the Davey-Paxman arrangement are, that the tubes are slightly tapered at their lower ends, where they curve to join the sides of the firebox, and that they are fitted at their upper ends with deflectors, as shown, these deflectors being slightly concave on their under sides. The taper at the lower ends of the water tubes renders the latter more elastic, and also serves a good purpose by intensifying the rush of the water at the point where deposit would be most likely to be formed; while the deflectors at the top divert into a horizontal direction the strong upward current of water which rises through the tubes when the boiler is at work, and thus prevent water from being thrown up into the steam space, so as to cause priming. That they serve this purpose very effectually, Messrs. Davey, Paxman, & Co., have proved at several of the Royal Agricultural Society's meetings, by showing one of their boilers at work with the manhole cover off, and with the deflectors removed from the mouths of some of the tubes. Under these circumstances the tubes not fitted with deflectors are seen to throw occasional jets of water nearly to the top of the steam space, while by the deflectors this action is wholly prevented. The Davey-Paxman boiler is a very efficient steam generator, and about three years ago we were present during a very careful trial of one of these boilers, when the quantity of water evaporated at atmospheric pressure was 9·5 lb. per pound of coal consumed, the water being supplied to the cast-iron base of the boiler at a temperature of 56 deg., and being pumped into the boiler at a mean temperature of 105 deg., this rise of temperature in the cast-iron tank base being in this case of course wholly due to heat communicated from the fire by induction or conduction. The fuel used was, in this experiment, Annesley coal of good quality, and the evaporation was effected at the rate of 3·04 lb. of water per hour per square foot of heating surface.

To return, however, to the engine and boiler which form the special subject of this notice. The general arrangement of the engine will be seen at once from the engravings on Pl. LXXI., Figs. 1 to 5. The cylinder is thoroughly steam-jacketted, and the valve chest has two compartments, the one containing the ordinary slide valve, and the other the expansion slide. The first-mentioned compartment is only just large enough to allow of the necessary motion of the main slide, and it communicates with the second or outer compartments by gridiron openings, which are opened and closed by the expansion valve. This latter valve has a very short travel, and it receives its motion from a cam on the crank shaft, as shown, this cam having a varying contour, and being shifted to and fro on the crank shaft by the action of the governor, as

will be seen from Fig. 3, Pl. LXXI. According to the position of the cam on the shaft, so a longer or shorter admission of steam is given, the amount of expansion being thus directly controlled by the governor.

The engine of which we are now speaking, is also fitted with a very good arrangement of feed heater, which we illustrate in detail by Fig. 5, Pl. LXXI. In this arrangement the pump delivers the excess of water, beyond that required for the boiler, into a vessel so formed that the water falls down through a perforated plate into the tank, the shower meeting on its way a jet from the exhaust, and thus becoming heated. By circulating through the pump and heater in this way, the water in the tank from which the supply for the boiler is taken, is effectually heated. In conclusion, we should state that all the working parts of the engine at Vienna are very well proportioned, and that the workmanship and general finish are excellent throughout. There was also a second Davey-Paxman engine of somewhat smaller size shown at Messrs. Clayton and Shuttleworth's stand. Messrs. Robey & Co. (Limited), had a very neatly constructed 4 horse-power engine similar in design in many respects to the last mentioned, but with a Field boiler.

France was very well represented in combined engines, and they were almost all well placed in the machinery hall. Messrs. Buffaud Frères, of Lyons, exhibited (with a number of other machines) two engines with Field boilers, of 2 and 4 horse-power respectively. These engines showed very beautiful and finished workmanship, yet were without such a display of polishing as would lead one to suppose they were made only for show. The arrangement of the different parts, also, and the general solidity of the machines, showed that they are intended to do actual work—indeed, there seemed considerably more metal than was at all necessary in some places. According to the design of these makers, the engine itself is vertical, with the cylinder below. A strong upright bedplate extends the whole height of the boiler, and the bearing brackets, guides, &c., are cast with it. It is bolted to the boiler above and to the cast-iron boiler seat below. The feed pump is cast on one side of the cylinder, symmetrically with the slide valve, but means are taken to prevent any consequent cooling of the cylinder. The feed water is heated by the exhaust in a simple reheater cast with the cylinder. The larger engine is fitted with a "Buss" governor, of which Messrs. Buffaud Frères are the sole makers in France.

Messrs. Maulde, Geibel, and Wibart, of Paris, who exhibited a number of printing machines, showed with them a 4-horse power combined vertical engine and boiler. A cast-iron cylinder (made in halves) is placed round the boiler, and serves as the frame for the engine, which in this way is nowhere rigidly connected with the boiler. This cylinder has, of course, large openings in its sides, both for the sake of lightness, and to get at the firedoor and other openings in the boiler shell.

The firm of Hermann-Lachapelle, of Paris, exhibited three well made and very neat little combined engines of, 1, 3, and 6 horse power respectively. The boilers are vertical, and have cross tubes in the firebox. The engines are not supported by the boilers, but on an arched frame consisting of two columns and a tie-piece above, which latter crosses the top of the boiler. These engines are well made, and much lighter than those last mentioned, with nearly the same stiffness. A little more metal judiciously employed in feathers at the sides of the columns near the base would probably make them all that could be desired.

Messrs. St. Chevalier and Grenier, of Lyons, had in the Machinery Hall, two combined engines with horizontal boilers of a peculiar construction. Their workmanship was rough, and in many places metal was quite thrown away, but still the engines possess some interest. The larger one is a compound engine of about 15-horse power nominal. The engine is horizontal, and set on a very heavy bedplate, which covers the whole top of the boiler. The cylinders are cast inside the dome, and in one piece with it. The piston rods are fast to the opposite ends of the same crosshead, and a large cylinder attached to this crosshead working inside a hollow bracket forms the guide. There is no means of tightening up the guide faces, the surface on which, although it seems large, is badly distributed. The engine can either be

worked without a condenser (in which case the exhaust passes through a feed heater on its way to the chimney) or with one. The condenser is a vertical cylinder, and the air pump stands on the level of the floor quite detached from the engine. It lies at an angle, and is single acting, and is worked by an eccentric on the main shaft. The boiler is of the return tube type, and both the furnace and the tubes are removable. At the back end the furnace, which is cylindrical, tapers somewhat, and its plates are flanged so as to bolt to the back plate of the shell. It is closed by a double door, with an internal baffler. The tubes are horizontal for the greater part of their length, but are bent round at the back, so as to communicate with the firebox, as shown in the sketch, Fig. 12, Pl. LXXI. A smokebox is thus dispensed with, and the tubes, of course, come out along with the furnace and front of the boiler. The smaller engine is of about 5-horse power nominal. It has a single-cylinder engine placed horizontally on the top of a boiler, similar to that just described. In the Agricultural Hall the Société Centrale de Construction de Machines, Pantin (Seine), had a very neat horizontal engine on a return tube boiler, and having a feed heater cast in the bedplate; the same firm also showed a larger similar engine at work in a shed outside.

Messrs. J. Belleville and Cie. (Paris) exhibited several of their "generateurs inexplosible." These are combined engines and boilers of a somewhat unusual construction. The boilers have been already described in the section dealing with those exhibits. On one end of the boiler casing are the furnace and smokebox doors, and on the other end is bolted the engine, which is vertical, and set on an extremely heavy bedplate. The machines are neatly arranged and intended to work up to nine atmospheres, but some parts of them are heavy out of all proportion, even for this pressure. The piston rod head, for instance, is of cast iron, and in size bears no insignificant proportion to the cylinder itself. The bedplate also might have half its metal deducted with advantage, and yet in spite of the superfluous strength in these places the cylinder covers are made square, and secured with only four bolts, one at each corner. The engines have Pickering governors, acting direct on the throttle valve spindle.

In concluding our notice of the French combined engines and boilers we must not omit to notice the neat little "domestic" steam engine of M. Hippolyte Fontaine. This engine is illustrated on Pl. LXXVII. Referring to the vertical section, fig. 1, it will be seen that the apparatus consists of a vertical boiler heated by gas and carrying on its top a small steam engine of very simple construction. The boiler is $9\frac{1}{2}$ in. in diameter by 1 ft. 10 in. high, and its ends, which are formed of $\frac{5}{16}$ in. plates, are bolted to angle iron rings, which are rivetted to the barrel, as shown. The top plate of the boiler carries the engine, steam cock, filling tube, and the apparatus for regulating the pressure which we shall describe presently; while to the bottom plate are attached the tubes, smokebox, and steam chamber. This construction gives every facility for inspection or repairs.

The boiler is, as we have said, heated by gas, this being burnt in a number of Bunsen burners arranged as shown. The heated products of combustion pass up through the tubes into a submerged smokebox made of cast-iron, this smokebox communicating with a descending flue leading to the chimney, as shown. Passing through the top of the smokebox is the steam chamber, which extends almost from the top of the boiler down into the descending flue just mentioned, the part contained in this flue of course acting to some extent as a superheater, and assisting materially in securing a supply of dry steam. The pipe by which the steam is taken off to the engine, passes down nearly to the bottom of this steam chamber, as seen in Fig. 1. The boiler is protected by careful cleading, so as to prevent, as far as possible, all loss of heat, and it is of such capacity that it can contain sufficient water for an entire day's supply.

We must now describe the arrangement employed to regulate the supply of gas and maintain the steam at a constant pressure. This arrangement is shown to an enlarged scale in Fig. 6. It consists of a brass plug screwed into the top of the boiler, and carrying a corrugated metal tube, from the top of which a weight is hung by a rod, as shown. The corrugated tube just

mentioned is enclosed in a casing provided at the top with an inlet passage through which gas can enter from the main, while at the side there is an outlet through which the gas passes to the burners beneath the boiler. The top of the corrugated tube carries a flat surface, which is directly opposed to the inlet opening in the casing, and thus as the corrugated tube elongates or contracts the opening for the admission of gas to the burners is diminished or increased. The elongation of the corrugated tube is caused by the pressure of the steam as the latter rises, and the adjustment of the apparatus is such that the steam is maintained at a practically constant pressure, however much the demand for it may vary. The gas regulator thus serves the purpose of a safety valve, while it also prevents any waste of gas from taking place. We should state that the arrangement is such that the gas is never entirely cut off from the burners, the latter being kept always alight, although the supply of gas may be so much reduced that it is only sufficient to supply the loss of heat by radiation, &c.

The construction of the engine is clearly shown by the enlarged views, Figs. 2 to 5, Pl. LXXVII. The diameter of the cylinder in the engine illustrated is $1\frac{1}{4}$ in. and the stroke is $1\frac{3}{4}$ in. The crosshead to which the piston rod is attached works in a tubular guide, and the slide valve, which is of the section shown in Figs. 3 and 4, works in a cylindrical casing. The whole construction is, in fact, exceedingly simple, and is such as permits of the engines being manufactured very economically. The arrangement for oiling the crank shaft is clearly shown by Fig. 3, and it will be noticed, also, from the same figure that the crossheads of the piston rod and valve spindle are of a cup form, so as to contain a supply of oil. The flywheel has a grooved pulley cast in one piece with it, and from its position a band can be readily led off from the pulley to any machine to be driven. The pressure of steam at which the boiler is worked is 110 lb. per square inch, and the engine is run at 300 revolutions per minute, the steam being cut off at one-fourth of the stroke. The slide valve, we may mention, has a small amount of inside clearance.

The boiler is filled through the funnel shown in Fig. 2, and, as we have said, its capacity is sufficient to contain water for a whole day's supply. All that has to be done, therefore, is to fill the boiler in the morning and light the gas, when the engine will run all day without requiring further attention. The speed is governed by a cock, which regulates the supply of steam, and, as we have explained, the quantity of steam generated is exactly adjusted to the demand by the gas-regulating arrangement. In the engraving the exhaust pipe is shown led into the flue through which the products of combustion are led off, but, where desirable, the exhaust steam can be utilised for heating water or similar purposes. Altogether, M. Fontaine has produced a very useful and well-planned little engine. M. Fontaine also exhibited at Vienna a larger engine capable of developing three times the power of that we have just described. To this larger engine, the construction of which is characterised by some very ingeneous details, M. Fontaine has given the name of *homme-vapeur*.

Messrs. Backer and Rueb, of Breda (Netherlands), exhibited a small combined engine. The boiler is vertical, and stands on a cast-iron sole plate. The engine is vertical and inverted, and stands on a separate framing at a little distance from the boiler, to which, however, it is connected at the cylinder end by a bracket. The only special point about the engine is the great simplicity of the governor, which really consists of nothing but the spindle and the two arms with the balls. It will not certainly be extremely delicate in its action, but probably quite sufficiently so for such an engine, and it is certainly not liable to get easily out of repair.

Italy sent one combined engine and boiler, made by Messrs. Guppy and Co., Naples, and her credit was certainly not enhanced by the exhibit. It is a horizontal return tube boiler, with an engine on top; the work is rough, and the proportions in many places faulty. The guide is a single bar of cast iron, about 3 in. × 4 in., the piston rod head works above and has a cheek down each side of it, the cheeks being connected underneath by a cap. The eccentric rods are connected to the slide spindles not by a joint

but by a short distance piece, with a socket and key at each end, and to allow for the spring this piece is flattened out in the middle.

In the Swiss section there were no actual engines belonging to the class of which we are now treating, but Mr. B. Morell, of Berne, exhibited drawings of a form of combined engine and boiler, designed by him, and which is illustrated by Figs. 1, 2, 3, and 4, Pl. LXXII). The inventor claims that the engine itself is the simplest that can be made, and that in the boiler he has obviated two great objections to vertical boilers, namely, the liability to prime, and the likelihood of leakage at the bottom of the tubes and the cracking of the tube plate. The engine is compound, with cylinders 3 in. and 6 in. in diameter respectively, and 9 in. stroke. The boiler is 3 ft. in diameter (3 ft. 6 in. over the steam casing), and 5 ft. high, and contains 28 tubes, $3\frac{3}{4}$ in. in diameter, besides one centre tube $8\frac{3}{4}$ in. in diameter. The total heating surface, not including the feed heaters, is 200 square feet, and the grate surface is 8 square feet. The boiler pressure is 90 lb. per square inch, and the engine is intended to work at 10 effective horse power with 350 revolutions per minute.

The two cylinders are cast together; they have no slide valves, but the distribution of steam is effected by the ports passing openings in the top of a semicircular box on which the cylinders oscillate. It is expected that the face of this box and that of the cylinder will be kept steam-tight by screwing down the two levers which encircle the latter. The cut-off in the high pressure cylinder takes place at $\frac{3}{4}$-in. stroke, but this entails the disadvantage that the port is not opened till the piston is nearly at quarter stroke, rather a rough way of working expansively.

The boiler is set on a large brick furnace, the products of combustion passing through an opening in its roof, the bricks of which will be of course be made red hot, before touching the boiler. This is an old method of preventing smoke, but we think it doubtful whether by it the gases can be freed from all materials which will exercise a deleterious influence in the bottom tube plate, as the patentee seems to expect. The furnace door has a hopper cast on it, through which the fuel can be introduced and pushed into the furnace by a cross which can be turned round by hand. As this cross does nothing whatever in the way of distributing the fuel on the grate, the door would have to be opened every time fresh fuel was put on, in order that it might be arranged by a poker or shovel in the usual way, so that the use of the cross is not very obvious. There is no means of admitting air above the level of the grate bars without opening the furnace door, a defect that ought certainly to be remedied. The boiler is a simple vertical cylinder traversed throughout its length by the tubes before mentioned. The centre tube is made larger, so that the draught may be regulated by a damper over its upper end. The other tubes are ferruled at the top, the size of the holes in the ferrules depending on the nature of the fuel used. The way in which priming is prevented is by rivetting round the whole upper half of the boiler an outer shell, leaving between it and the boiler proper a space of about $2\frac{1}{2}$ in. A number of small holes round the top of the shell communicate with this annular steam chest, and any water that passes through them will, it is expected, be evaporated before it reaches the steam pipe. The whole boiler is enclosed in a cast-iron casing or smokebox, and the products of combustion pass down this casing—enveloping the boiler—on their way to the chimney. In the flues just behind the furnace, through which the gases pass after leaving the smokebox, are two cylindrical cast-iron vessels, connected by an inclined pipe. Both of them communicate direct by vertical pipes with the boiler. The feed water is introduced into the bottom of one of them, and a circulation is expected to be kept up through the inclined tube, up into the boiler, and down again so vigorously that all deposit is to be brought down into one of the boxes, from which it can be easily blown off. It is easy to see how the feed water will rise, but how a downward current is to be induced from the hottest part of the boiler into these comparatively cool vessels (from which, at the same time, the feed must continually ascend), is not so comprehensible.

In spite of the ingenuity of this engine, and of some good points about the boiler, it has several obvious objections which will—we are afraid—be

sufficient to prevent it coming into general use. One advantage of a vertical boiler of the usual kind is that it is self-contained, and requires very little setting, while this one requires a large fire-brick furnace and flues. The exhaust steam will not make a very efficient blast if it is only admitted into the base of the chimney at a considerable distance from the boiler, and there does not seem any way of using it sooner. It will, therefore, be necessary to have a higher and more expensive chimney than is generally the case with vertical boilers. In addition to this the defective distribution of the steam in the cylinders will make itself felt unless the engine runs at a higher speed than 525 ft. per minute, which, although high, has been reached even by engines of the ordinary construction, and much exceeded by some constructed like this one, specially for driving fans, &c. direct. With 8 ft. of grate and 200 ft. of heating surface no doubt much more than the 10 effective horse power named by Mr. Morell would be obtained, and there is no reason why the boiler should not rather work at ten or twelve atmospheres than at six.

In the German section Messrs. Scharrer and Gross, of Nuremberg, exhibited a vertical boiler with a horizontal engine, the soleplate of the one being also the bedplate of the other. The feed pump is in a line with the cylinder in front, and being worked direct by the piston rod forms its guide. The connecting rod is of course sufficiently forked to allow it to pass over the pump. The engine has a feed heater, and also an expansion valve, the cut off of which can be varied by moving the eccentric. Messrs. Lange and Gehrkens (Ottensen) showed a small vertical boiler with engine, the latter being entirely unsupported by the former. The firebox at the level of the grate is made with dry sides on account of its small diameter, higher up it is fitted with cross tubes. The Sächsische Dampschiffs und Maschinenbau Anstalt, Dresden, in addition to the horizontal engine we have before noticed, and other machinery, exhibited a 5 horse power combined engine with a cylinder 200 mm. (7·87 in.) diameter by 340 mm. (13·38 in.) stroke. In general arrangement, this engine, which is illustrated by Figs. 10 and 11, Pl. LXXI., is similar to those of Hermann-Lachapelle, which have already been described. The place, however, of each cross tube in the firebox is taken by a nest of six smaller tubes, which will probably be slightly more efficient.

The firm of R. Wolf, of Buckau-Magdeburg, Prussia, exhibited a combined horizontal engine and boiler, the speciality of the latter being that the firebox and the whole of the tubes can be taken out to be cleaned—by no means a new feature. The cylinder (about 10 in. by 18 in.) with slide chest, &c., is cast in the dome, so that it is always enveloped in steam. The top of the boiler is covered with a heavy bedplate, which supports the plummer blocks, guides, &c. The feed pump stands in front of the slide chest, and it is worked by the valve eccentric, its plunger forming a guide for the valve spindle. The boiler is of the direct multitubular type with smokebox at the opposite end to the furnace. The back tube plate is quite separate from the back of the boiler, and is bolted to it from the inside. The front end of the boiler, to which the furnace is rivetted, is bolted to outside angle irons right round. By loosing, therefore, two rings of nuts, the whole inside of the boiler can be freely taken away, and Herr Wolf claims that it can be cleaned and fitted again in place with the joints made in two days. As we have said, however, the plan is far from being new, the arrangement is simply a modification of Mr. Biddell's boiler, made by Ransomes and Sims many years ago. In the Eastern Agricultural Hall, C. Rudolphe & Co., of Neustadt, Magdeburg, had a small vertical engine and boiler, which does not call for special mention.

Herr J. Haag, of Augsburg, exhibited several small engines, one of them combined with a vertical boiler, constructed on Schmidt's system. In Schmidt's engines the cylinder lies horizontally and oscillates on trunnions, while at the same time the face of its ports, being made part of the surface of a cylinder concentric with the trunnions, works always upon a similar fixed face in the bedplate. In order that these two faces may be kept tight the trunnions do not work in fixed bearings, but in the ends of levers which can be tightened downwards at pleasure. These engines we shall describe more in detail under the head of "Steam Pumps," the inventor himself having exhibited a small pump made on his principle. Herr Haag has added to Schmidt's engine

a variable expansion valve, which is made to rock on a spindle underneath the fixed port face, and is actuated by a cam on the shaft. This valve of course destroys the great simplicity of the engine, but at the same time enables it to work economically, which otherwise it could not do.

The Austrian exhibits only included two combined engines. The more important was shown by the Fürst Joh. Liechtenstein'sche Maschinen Fabrik und Eisengiesserei, of Adamstal, near Brünn. It is a double cylinder engine of 16 nominal horse power, working underneath a locomotive boiler. The engine is strong and pretty well made. A bracket cast on the cylinders supports the smokebox end of the boiler, expansion valves of the usual kind are fitted with hand gear for regulating the cut-off. The governor is Buss's patent, and works a double-beat valve. The bedplate of the engine forms also the footplate for the firebox of the boiler. The Erste Brünner Maschinen Fabriks Gesellschaft, of Brünn, a company which we have already had occasion to mention more than once, exhibited with the rest of their machinery, a 6 horse power horizontal engine combined with a vertical boiler. The boiler is of the common multitubular type, the flame passing through a great number of small vertical tubes between the top of the firebox and the top of the shell. A kind of baffle plate or partition placed in the furnace is used to prevent the flame rushing too readily up the tubes. The engine is fixed to the boiler soleplate, and derives no support from the boiler itself. There is nothing, however, about it which calls for special mention.

Portable Engines.

It was generally admitted by all who examined the agricultural exhibits at Vienna that in this department, at all events, England did more than hold her own; and there was, in fact, no other nation whose examples of agricultural machinery could bear a moment's comparison with those sent by our own makers. The leading English agricultural engineers have, as is well known, for many years past made vigorous progress in introducing their manufactures abroad, and in doing this they have gained an amount of practical experience concerning the requirements of various countries and different systems of agriculture which renders them *facile princeps* in any competition with Continental makers. It is our intention in a future section to describe in detail the more noticeable examples of agricultural machinery shown at Vienna; at present, however, we only propose to speak of the agricultural engines exhibited, and to point out any special peculiarities by which they are characterised.

And here we may remark at once that in the British department, although we found plenty of things which were good, we discovered little that was really novel in the way of portable engine construction. It is at the shows of the Royal Agricultural Society that novelties are generally brought forward by our leading firms, and in preparing their exhibits for Vienna our makers appear to have determined to show the best results of experience already gained rather than novelties, of which the practical value had yet to be proved. Under these circumstances our notice of the British exhibits must necessarily be a somewhat brief one, as it is useless for us to enter into minute descriptions of engines with the details of which our readers are perfectly familiar.

On entering the Western Hall for agricultural machinery by the door next the British section of the Industry Palace, we came first upon one of Messrs. Aveling and Porter's 8-horse agricultural locomotives of the well-known Rochester type; but with several minor improvements in matters of detail calculated to improve an already excellent engine. Outside the hall, the same firm showed their new road roller, illustrated by us on Pl. LXXIII., Fig. 1, this roller having previously been employed in doing good service on the roads in the Prater, prior to the opening of the Exhibition. This steam road roller is of a new pattern, patented by Mr. Aveling. It will be seen, on reference to the illustration, that instead of the steering wheels being at the back of the firebox, as in Messrs. Aveling and Porter's former type, they are at the leading end, and carry that end of the boiler without the intervention of any framing. The machine is, in fact, as nearly as possible a traction engine with very broad wheels, those

at the leading end being placed close together, so that they roll the space which would otherwise be left between the tracks of the hind wheels.

The leading wheels are, as will be noticed, made somewhat conical, and they are mounted on a dead axle of which the ends are deflected downwards, so that the wheels are brought together at their lower and spread at their upper edges. This arrangement enables a strong centre pin, bolted to the leading axle, to be carried up between the wheels as shown, this centre pin passing through brackets projecting from the smokebox. A collar on the pin takes a bearing against the lower bracket, and the holes in the latter are formed so that the centre pin can not only rotate freely, but can rock to a limited extent, so as to allow the leading wheels to adjust themselves to the curve of the road surface. The outer ends of the leading axle are connected by a bow or frame as shown, which serves to receive the steering chains, the engine being steered by the driver from the footplate.

At the trailing end the arrangement of the machine is similar to that of Messrs. Aveling and Porter's well-known agicultural locomotives, the crank shaft, &c., being supported by wrought-iron brackets formed by extending upwards the side plates of the firebox casing. The mode of carrying the cranks haft bearings saves much dead weight, and substitutes simple rivetted work for brackets bolted to the boiler, and it is in fact in many ways such an improvement on the old system, that Messrs. Aveling and Porter are now adopting it for all their engines.

The steam road roller we have described was an excellent piece of work. As a road roller it performs admirably, as we can testify from personal inspection, while the simplicity of its construction renders it a decided improvement upon the former rollers by the same makers, thoroughly good as those rollers have proved themselves to be. The roller exhibited at Vienna, shown by the illustration, weighs 7½ tons; but Messrs. Aveling and Porter are making machines of the same type of much larger sizes.

Another exhibit sent by Messrs. Aveling and Porter was one of their handy little traction engines with a crane at the smokebox end. We illustrate one of these engines on Pl. LXXII., Fig. 5, the engine there shown, however, not being the one actually exhibited at Vienna, the differences consisting in the mode of attachment of the back-stays of the crane-jib, and in the fact of the engine shown by our engraving being fitted with the late Mr. W. B. Adams's elastic tyres. The engine illustrated is in fact of a later pattern than that shown at Vienna, but the explanation just given will enable the differences to be readily understood. Referring to the engraving it will be seen that the engine has a single cylinder and has the side plates of the firebox carried up so that there can be attached to them all the bearings of both the road and hoisting gear. This mode of forming wrought-iron brackets by carrying up the sideplates of the firebox casing has for some time been adopted by Messrs. Aveling and Porter for their traction engines, and it makes an excellent job, at the same time effecting a material saving in dead weight. In the present instance these side plates are also utilised as points of attachment of the back stays for the crane jib, as shown in the illustration, the plan adopted in the engine exhibited being to attach these stays to the smokebox. The length of the stays is adjustable as shown. The general arrangement of the working gear is similar to that usually adopted by Messrs. Aveling. The cylinder is, of course, steam-jacketed, and the working gear is screened by side plates as shown. The driving wheels of the engine shown in our engraving have, as we have said, the late Mr. W. B. Adams's elastic tryes, india-rubber being interposed between the tyre proper and the inner tyre, to which the ends of the spokes are rivetted. These wheels are now fitted by Messrs. Aveling with an arrangement which effectually prevents the wheel moving round in the tyre, and at the same time leaves the india-rubber free to exert its elastic action. The road gear includes compensating gear on the driving axle. The clutches for actuating the road and hoisting gear are conveniently arranged, as is also the steering gear, so that a boy is able to work the engine entirely without assistance. Altogether, the general design and workmanship of the engine are excellent, and the whole machine is one which is calculated to do good work in a great variety of situations.

Passing Messrs. Aveling and Porter's stand we found Messrs. Wilsher and Co., of Braintree, with an ordinary portable requiring no special comment, and next to it an engine from Messrs. Wallis and Steevens, of Basingstoke, fitted with their annular space water heater. Of this heater we give on Pl. LXXIII., views which will explain its construction. The heater consists of a casting K of the cross section shown in Fig. 7, fixed longitudinally by the side of the boiler with a slight dip towards the front end, and connected at B (Fig. 10) with the exhaust pipe by a suitable branch. The exhaust steam entering by this branch traverses the heater from end to end and passes through the outlet C to the blast nozzle in the chimney, that portion which is condensed being drained off at H into the feed tub. The feed-water, on the other hand, is delivered by the pump through the inlet pipe I, and that portion which is required for the boiler traverses the tubes F of the heater, finally passing off the through the pipe J, and entering the boiler through a check valve. The pump is always kept full on, the excess of the water delivered by it beyond that required for the boiler being led back into the feed tub through a pipe connected to the inlet chamber at A, this pipe being fitted with a regulating cock. It follows from this arrangement that the excess of water does not traverse the heater.

The tubes F through which the feed water passes are, it will be noticed, each traversed by a rod G, these rods being maintained in a central position in the tubes by their ends entering suitably placed sockets formed in the end covers, E, of the heater. By the insertion of these rods the water is caused to flow through narrow annular spaces in direct contact with the heating surface, while by the removal of the rods the interiors of the tubes are left clear for cleaning. The currents of steam and water, it will be noticed, flow in opposite directions, and the heater is altogether a very compact and efficient one.

Next came Messrs. Robey and Co., of Lincoln, with a fine show of portables in all the glory of polished mahogany lagging and high finish, but still of the ordinary types made by the firm. These engines had all steam-jacketted cylinders and feed-water heaters, and one of them was fitted with Mr. Richardson's governor acting on the eccentric, and varying the expansion. Of this governor we give detail views on Pl. LXXII., Figs. 6 and 7. Referring to these views, it will be seen that that portion of the crank shaft on which the eccentric is placed, is of square section, and that the eccentric itself has a slot cut through it to fit this portion of the shaft. This slot is of such length, and is so placed that the centre of the eccentric can be shifted from the position which it would occupy in an ordinary engine of the same proportions, to one in which it is situated directly in a line with the crank, but on the opposite side of the centre of the crank shaft. In this latter position the centre of the crank shaft and eccentric are separated by a distance equal to the lap of the valve plus the lead, and the motion given to the valve is similar to that which it would derive from an ordinary link motion in mid gear.

The eccentric is shifted from one to the other of the extreme positions just mentioned, by means of a pair of wedges arranged, as shown in Fig. 7, Pl. LXXII., these wedges sliding on keys or feathers fixed in the crank shaft. The arrangement is, in fact, very similar to Dodd's well-known wedge motion; but instead of being employed for the purpose of reversing the engine, it is used by Messrs. Robey as a means of regulating the degree of expansion, and is, moreover, rendered self-acting by connecting the wedges directly to the governor. The manner in which this connexion is made is so simple, and is so clearly shown by the views given, that but little explanation will be necessary. As the governor balls diverge, the arms—which are connected by links to a collar fixed on the crank shaft—draw the wedges through the eccentric, and in doing so shift it from the position which it occupies when in full gear; the effect being that the greater the divergence of the balls the more the throw of the eccentric is reduced and the earlier is the steam cut off, the lead, however, remaining constant. On the contrary, when the speed of the engine is reduced the balls are drawn towards the crank shaft by

the action of the spiral spring interposed between the fixed and movable collars, and the throw of the eccentric is increased by the corresponding movement of the wedges. The range given on the engine we are describing is such that the point of cut-off can be varied from $\frac{1}{8}$ to $\frac{3}{4}$ of the stroke, the point at which suppression occurs in the course of regular work being about $\frac{1}{3}$ of the stroke. We have examined indicator diagrams taken from an engine fitted with this arrangement when the cut-off took place at the point just named, the piston speed being at the time 267 ft. per minute, and they showed a very good action of the valve gear. The arrangement is, moreover, very sensitive, and effectively controls the engine.

The Reading Iron Works Company sent to Vienna an eight-horse portable engine similar to that which gained them so much credit at the engine trials of the Royal Agricultural Society carried out during the Cardiff show of 1872, the boiler, however, having a smaller fire-box than that sent to Cardiff. Of this engine a perspective view is given on Pl. LXXIII. The cylinder is, of course, steam jacketted all over, including covers, the connexion between the jacket and the boiler being made by two passages, each furnished with a cock, so that, if desired, the communications can be closed. The distribution of the steam is effected by a pair of short slides, with expansion valves at the back, the lap of the expansion valves being adjustable by turning the screwed spindle. The degree of expansion is under the control of the governor, the sliding sleeve of the latter having a number of grooves cut in it, so as to form a kind of circular rack, which gears into a toothed quadrant. This toothed quadrant is at one end of a kind of rocking lever, the other end of which carries another toothed quadrant, gearing into a pinion on the expansion valve spindle. The whole arrangement is very simple, and neatly carried out.

As will be seen from the dimensions given below, the firebox was in the case of the Cardiff boiler unusually large. The tubes are spaced a good distance apart, and they are of large diameter; but during the trial run at Cardiff, the area through them was diminished by the use of contracting ferrules at the smokebox end. The engine was also run with a very small firegrate area, the fire being kept exceedingly thin. The feed water is pumped through a heater in the smokebox.

Of the general proportions and workmanship of the engine we cannot speak too highly. They reflect the greatest credit upon the makers, and especially upon the late Mr Alfred Barrett, under whose immediate direction the similar engine was constructed and "trained" for the Cardiff competition. Of this latter engine (which was as we have stated, with the exception of the boiler, identical with that exhibited at Vienna) we append, for convenience of reference, the principal dimensions, and also notes as to the results obtained with it at Cardiff:—

	ft.	in.
Diameter of cylinder	0	$8\frac{1}{2}$
Stroke	0	14
Length of firebox inside	2	6
Width „ „	2	$9\frac{1}{4}$
Height „ above firebars	3	2
Number of tubes	39	
Diameter of tubes outside	0	$2\frac{3}{4}$
Length „ „	6	0
	sq. ft.	
Ordinary firegrate area	7·2	
Area of firegrate used during trial	2·37	
Aggregate area of spaces between firebars as used on trial	0·91	
Heating surface; tubes (outside)	167·5	
Firebox	39·4	
Total	206·9	

Area of heating surface per square foot of fire-grate area	90·4
Diameter of blast nozzle	2 in.
Nominal speed in revolutions per minute	140
Mean " " "	138·4
Mean piston speed in feet per minute	322·9
Load on break	17 H.P.
Mean indicated power during trial, calculated at nominal speed	20·58 H.P.
	hrs. mins.
Actual time run with allowance of 14 lb. of coal per dynametrical horse power	4 55¼
Mechanical time = total number of revolutions ÷ nominal speed	4 51·6
	lb.
Consumption of coal per dynametrical horse-power per hour	2·88
Consumption of water per dynametrical horse-power per hour	29·2
Consumption of water per indicated horse-power per hour	24·14
Water evaporated per pound of coal	10·49
Coal burnt per square foot of firegrate	21·2

It should be added that the consumption of water above stated, and also the quantity of water evaporated per pound of coal, do not include the water which drained back into the boiler direct from the steam jacket. What this quantity was there was no means of measuring, but it probably amounted to quite 8 per cent. of the whole.

Messrs. E. R. and F. Turner, of Ipswich, exhibited at Vienna a portable engine exactly like that which they sent to the Cardiff trials in 1872. This engine, which is illustrated in Pl. LXXIV., Figs. 1 to 4, is of a type which includes several special peculiarities, and it has been designed by the manufacturers to be more economical of fuel, without being more complicated, and more powerful and suited for high speeds and pressures without being heavier, than the ordinary portable engine. Its construction embodies the patents of the manufacturers for their slide valve, and of Messrs. Hartnell and Guthrie for their system of framing and governor. The engine is complete in itself independently of the boiler, the latter being relieved from the great strain generally thrown upon it by the cylinder and crank shaft brackets. The material has been economised by placing it in line with the principal strains, and the number of separate parts has been reduced as far as possible. The cylinder casting includes the piston valve case, the starting valve, safety valve, and steam jacket, there being no other casting bolted to the top of the boiler, save the extra safety valve seating. The crank shaft bearing blocks are of wrought iron, and forged to the side frames. There is but one guide bar, its outer end resting on the cross stretcher connecting the frames. The direct pull of the connecting rod and the torsion through friction on the crank shaft bearings being resisted by the frames, the crank shaft supports have merely to bear a vertical strain, and each consists of a small plate directly under the crank shaft bolted transversely to the barrel. To one of these plates—and not to the barrel as usual—is fixed the pump.

The cylinder is 9 in. in diameter, the stroke of the piston 12 in., the steam ports are 5½ by 1 in., and about 3¼ in. long; lap of valve ⅞ in., and exhaust port 5½ by 1⅛ in. The condensed steam in the jacket drains to the boiler. Steam is supplied to the engine by an independent passage from an internal pipe perforated near the smoke box end. The exhaust pipe passes outside the boiler, terminating in a 2⅞ blast orifice, some distance below the base of the chimney.

The piston valve is 6 in. diameter, packed by double rings at each end; the peculiarity consists in the rings being fixed on the side adjacent the ports

solid with the piston, but left free to expand on the other side, thus combining the freedom of an equilibrium with the tightness of an ordinary slide valve. The eccentric is acted on by the governor, which is enclosed in a drum, 18 in. in diameter, placed on one side of it on the crank shaft, the centre of the eccentric traverses, in an arc of $8\frac{1}{2}$ radius, from the point of full gear (either forward or backward) to that of mid gear, the expansive action being much the same as with the link motion.

The governor, of which we give detail views in Pl. LXXIII., Figs. 3, 4, and 5, is, as we have said, placed on the crank shaft close to the eccentric, which it adjusts. There are two governor weights each pivoted at one end, placed at opposite sides of the shaft and coupled so as to balance each other. The weights are pressed towards the shaft by springs which yield to the centrifugal force when the engine attains the proper speed, the weights opening and closing as the speed varies.

The eccentric is detached from the shaft, and swivels freely on a pin G near the outside of the governor case, the weights move the eccentric by means of a kind of scroll motion, which also enables them to hold it fast. The weights A and B turn on the pins C and D, and are connected by a rod. F F are the springs, which act by compression. The eccentric is carried by the pin G, and the weights move it by means of the forging (called the quadrant) H, which latter swivels on the pin K this pin being so placed, that when the weights are open, it stands under the pin L, in the eccentric, which is then in mid gear. The pin L embraces the quadrant, which is here drawn in mid gear. To put the engine in full gear, loosen the screw M, and push the eccentric against the shaft, moving the centre, say to N; tighten the screw again. This will have caused the quadrant to swivel on the pin K, and one end of the slot will be near the screw M. It will be evident that since that part of the quadrant which is over the pin K will still be in the same position as before, as the weights open and K approaches the pin L, the eccentric will be drawn towards mid gear. The travel of the quadrant being much greater than the transverse motion imparted to the pin L, it follows, from the laws of friction, that a force applied to that pin by the resistance of the valve will produce little or no effort to move on the governor. To reverse the engine, a key is inserted through the eccentric, the screw M slackened, the eccentric pushed to the opposite side of the shaft, and the screw again tightened.

The speed of the engine can be varied within certain limits by altering the tension of the springs, and any required degree of sensitiveness can be given by suitable springs. In the 8-horse power portable engine exhibited at the Cardiff show of the Royal Agricultural Society in 1872, with 80 lb. pressure in the boiler, the speed was 180 revolutions with 20-horse power on break, 186 when quite unloaded, while, according to a previous test, it was 177 with 30-horse power, and 183 with 5-horse power on the break. The variation for the mean was thus in actual work, less than 2 per cent.

The governor having heavy weights and revolving quickly, is very powerful. The springs of the above-named example exert a force of 70 foot-pounds, in closing the weights; the eccentric swivels with little friction, while the resistance of the valve twice in each revolution must act in the same direction as the governor. From these causes the governor acts with extreme promptness, allowing but little variation from the mean speed. If the whole load be removed suddenly, the superfluous steam is cut off instantly. The working parts are few and simple, provision is made for great durability, the pins and quadrant being case hardened, the weights furnished with hardened bushes, and the pin L has an adjustment. The springs are made with a great excess of strength. The governor has altogether been found to work in a very satisfactory manner, the actual saving of fuel in practice being greater than had been anticipated.

Returning now to the engine to which the governor was fitted, we must add some further particulars. The connecting rod is 3 ft. long, centre to centre; the crank pin bearing $3\frac{1}{4}$ in. in diameter, and the crank shaft, 3 in. in diameter. There is a counter-balance both in the flywheel and in a pulley on the other end of the shaft, arranged so that their resultant action is opposite the piston

rod. The water heater is of the same simple form as introduced by Messrs. E. R. and F. Turner, at the Oxford show of the Royal Agricultural Society in 1870, but improved in detail, requiring but one extra piece to be added to the pump, viz., the connexion between the exhaust pipe and the overflow jet. It always acts when the engine is working, and cannot become choked or get out of order; it heats the water in the feed tube to from 140° to 180°. The boiler is 2 ft. 8 in. in diameter, the barrel being flush with the firebox. It contains 55 tubes, 6 ft. 3 in. long between the tube plates, $1\frac{7}{8}$ in. outside diameter, in perpendicular rows, kept well clear of the boiler shell to allow a descending current of water. The area of the grate is $3\frac{1}{2}$ square feet, and the total heating surface 188 square feet.

The engine exhibited by Messrs. Turner was as we have said a duplicate of that sent to the Cardiff trials, but it was in no respect a racing engine; all the working parts being calculated to work continuously at 20-horse power, and the engine is one which will readily drive 30-horse power on the brake, suppressing at about half stroke with 80 lb. of steam, and being intended to meet the rough usage to which portable engines are not seldom subjected. On trial at Cardiff the grate was not bricked up, or the tubes ferruled, save with the usual thin steel ferrules. Although the single slide valve is not so economical as double slides (when the latter are carefully proportioned), yet the engine ran 3 h. 51 m. with an allowance of 14 lbs. of coal per brake horse power under disadvantageous circumstances, and an examination of the water consumed per horse power on the brake per hour showed that, in the hands of a highly-skilled fireman, it might have ran nearly as long as any engine tested, and was in itself about as economical of steam.

Messrs. Ransomes, Sims, and Head, of Ipswich, whose stand comes next on our list, were the exhibitors of one of the few novelties in portable engine building at Vienna, this being the 10-horse engine fitted with Messrs. Schemioth and Head's patent straw-burning arrangement, which is illustrated on Pl. LXXIV., Figs. 5 to 8.

On the extensive farms of the prairies of North and South America, steam has hitherto been little employed for agricultural operations—not because its advantage over animal power was disputed, but on account of the impossibility of obtaining coal or wood as fuel for the engines, except at a cost which would render their use almost prohibitive. In South Russia, the United Provinces of Moldavia and Wallachia, and some parts of Hungary, where a day's journey may be accomplished without seeing a tree, steam machinery has been employed for some time for the purposes of thrashing and grinding, in order to meet the demands of the export corn market; but the operation has been carried on at great cost to the farmer, most of the wood for fuel being brought in carts for a long distance, or if coal was used it was transported from the nearest port where it had usually arrived from England.

Although coal and wood are not indigenous in these countries, yet many vegetable products abound, such as straw, reeds, maize stalks, &c., which are capable of generating sufficient heat to keep up steam in the boiler, if a method was discovered to feed them into the furnace in such a manner that each separate piece might be exposed to the action of the fire, and a proper amount of atmospheric air admitted to produce continuous combustion; and as such fuel is always attainable on the spot, at almost a nominal price, it is self-evident that such a discovery would greatly extend the use of steam power in these districts.

In some parts of the West Indies and in Egypt, sugar cane trash has been for some time used as fuel, but usually mixed with coal or wood, and in South Russia and on the banks of the Danube, straw has been burnt in the portable engines in various ways; but the only one which can be admitted as at all successful was the following:—The bars were taken out of the firebox, and the engine was placed on a brick flue, running diagonally from the ground to the floor of a pit about 10 feet deep, one end of which was hermetically sealed to the bottom of the firebox, and the other terminated in a sort of oven, in which the straw was burnt. The heated gases passed up the flue, through the firebox and tubes of the engine to the chimney. This system was injurious to the lower part of the firebox, besides compelling the farmer to bring all his grain

in carts to the place where the engine was fixed, instead of taking the thrashing machine alongside each stack, which is a great saving of labour and expense.

To obviate these difficulties, Mr. Schemioth, a Russian engineer, conceived an idea that straw might be forced into the firebox of either a portable or fixed boiler in the form of a fan by means of rollers, so that each separate piece would come under the action of the flame, allowing more rapid combustion to take place than when the straw was fed into the furnace in a compressed state, and burnt in a slow smouldering manner. He communicated his idea to Messrs. Ransomes, Sims, & Head, of Ipswich, who forthwith commenced to make experiments, and after about 15 months' of continued trial, during which period much attention was given to the subject by Mr. Head, this firm produced the most perfect engine yet invented for burning straw and other vegetable products.

In some of the early experiments much trouble was experienced in obtaining sufficient atmospheric air through the bottom of the firebox, owing to a deposit of silicious matter which covered the bars with a sort of clinker, and after trying various schemes, the following simple method was found to be the most practical: the bars are placed about 4 in. apart, and between each pair is a blunt knife projecting about 2½ in. above them. Each knife is attached to a cross bar sliding on two guides under the grate, one end of this bar terminating in a long handle extending beyond the ash pan. When the bars require to be cleaned the fireman moves the knives backwards and forwards, giving them at the same time a side action, which cuts out the clinkers, these falling into the ash pan, where they are immediately quenched by a jet of cold water from the feed pump, thus avoiding any danger from the escape of the burning ashes in case of windy weather. The whole arrangement will be readily understood on reference to the engravings on Pl. LXXIV.

The apparatus for feeding the engine is self-acting, and driven by means of a strap, and steam may be got up in the same way as with any other combustible, by attaching a handle to the feeding rollers and turning them by hand (see Fig. 7) instead of by steam power. One man only is necessary to feed the straw into the engine, provided the material is brought to him and placed alongside the feeding trough. The average consumption is about four to five times the weight of coal, and according to experiments made, about 10 to 12 sheaves of straw are required to thrash 100 sheaves of wheat.

In the spring of 1873 we had an opportunity of witnessing at the maker's works, at Ipswich, a trial of an engine fitted with the apparatus of which we have been speaking, and exactly similar to that exhibited at Vienna. The engine was one of Messrs. Ransomes, Sims, & Head's ordinary 10-horse power portables, except that it was provided with a larger firebox than is used for coal burning, and that the tubes were of slightly smaller diameter than those ordinarily employed. The straw-burning apparatus was constructed precisely as shown by our engravings on Pl. LXXIV., and the straw burnt was in in its natural condition, and had not been subjected to any artificial drying process. On first lighting up, the rollers had of course to be turned by hand to feed the straw into the firebox, but this is very light labour, and can easily be performed by a boy. In 32 minutes from applying a light, the steam had got up to 20 lb. pressure, and the steam jet in the chimney was then opened. In eight minutes more, or 40 minutes from lighting up, the steam pressure had reached 31 lb., and the engine was then started, the steam jet being shut off, and the belt put on to drive the straw-feeding rollers. The steam pressure then began to rise rapidly, and in 11 minutes more, or a total time of 51 minutes from lighting up, a pressure of 60 lbs. was reached. Subsequently, the pressure was raised to 70 lbs., and a brake, applied to the flywheel, was loaded so as to cause the engine to develop 20 effective horse power, the speed being 140 revolutions per minute. With this load steam was maintained steadily and with the utmost ease, the whole of the arrangements working admirably. The combustion of the straw was thorough and complete, only a very few stray particles of unburnt material occasionally finding their way into the ash pan, while by an occasional use of the rake or knives already mentioned, the grate bars were readily kept clear. The water jets in the ash pan also thoroughly fulfilled their purpose of preventing ignited par-

ticles from flying about—an important matter where thrashing is going on—and altogether the trial was a most satisfactory one in all respects.

Fig. 7 on Pl. LXXIV. represents a perspective view of one of these engines getting up steam, showing the position of one man feeding and the other turning the rollers by hand. Fig. 8 is a corresponding view, showing the engine fairly at work, while the other Figs. 5 and 6 consist of a section of the firebox and an end view. In these views, *a a* are toothed rollers fitted with malleable teeth, and connected with the engine by means of a pulley *b*, driven by a strap from the crank shaft. These rollers make 48 revolutions per minute, and can be turned by hand when getting up steam. The movable sliding blunt knives or rake *c c*, attached to a cross bar *d*, slide on guides *e e*, below the grate, as already explained. This rake can be moved with a forward and side motion by the stoker by means of the handle *f*, thus breaking up the silicious crust deposited on the grate bars *g*, while a perforated pipe *h* is provided for injecting water upon the burning ashes. A shoot *i* carries any small pieces of ignited straw back into the ash pan, and *j* is a wooden trough to contain the straw which is to be fed into the furnace, and which can be removed when the engine is travelling. The whole apparatus swings on a hinge *k*, and can be taken off in a few minutes, and the ordinary fire-door substituted when coal or wood is burned.

We consider this to be one of the most important steps that has been lately made in the construction of portable steam engines since their introduction, as they can now be used in any country where vegetable produce be raised, instead of as heretofore being practically restricted to those countries where coal or wood can be procured, and a wider extension is thus given to the opportunities for the employment of steam power than would at first sight be thought possible.

Besides the straw burner just described, Messrs. Ransomes, Sims, and Head also shewed one of their ordinary 10-horse engines, a 12-horse double-cylinder, and an 8-horse single cylinder, fitted with link motion, the expansion link being of the neat solid bar form which the firm have long used. All the engines at this stand were fitted with brakes to adapt them for use in hilly countries, the brake blocks being applied by a screw to a brake wheel secured on the inner side of one of the hind carrying wheels.

Passing on, we came to the stand of Messrs. John Fowler and Co., of Leeds, who, besides the collection of ploughs, &c., to be noticed hereafter in their proper place, showed a double-cylinder ploughing engine for working on the double-engine system, and a traction engine of one of their well-known types. The ploughing engines will be described in another section, while the traction engine, we may mention, had a steam jet pump or elevator fitted to the tank for the purpose of raising water from road-side ponds, and an injector, in addition to a pump, was provided for feeding the boiler. The workmanship of both the traction and ploughing engine was excellent.

Messrs. Marshalls, Sons, and Co., of Gainsborough, besides a very neat semi-portable engine, which we have already noticed, showed one of their ordinary 8-horse single-cylinder portables, and a 14-horse double-cylinder engine of the type which they brought out at Cardiff in 1872, with wrought-iron brackets for the crank shaft plummer blocks, the latter being free to slide on the brackets, and being connected to the cylinder by strong tie rods, which also carry the plate to which the guide bars are fitted. This was a thoroughly substantial and well-finished engine.

We may notice here that Messrs. Marshall, Sons, and Co., fit their engines with a very neat form of adjustable eccentric, patented by Messrs. Hartnell and Guthrie, and this eccentric we illustrate on Pl. LXXII, Figs. 8, 9, and 10. Referring to the views there given, it will be seen that there is keyed upon the crank shaft a disc having a straight slot cut in it, as shown in Fig. 10, this slot receiving the square shank of a bolt, which passes through the disc and eccentric. The eccentric itself has a hole cut in it, of the form shown in Fig. 8, so that it can be shifted transversely across the crank shaft; and it has formed on one side of it a feather, which fits into a corresponding groove or keyway cut in the disc already mentioned. By this means the eccentric is firmly secured to the disc, whilst by slacking the connecting bolt its centre can be moved in a

straight line across the crank shaft, thus varying the throw. An index finger formed on the head of the bolt working against a graduated scale marked on the disc, as shown in Fig. 10, enables the eccentric to be readily adjusted. By means of this arrangement, the degree to which the steam is expanded can be readily varied according to the kind of work the engine is called upon to perform. The effect of shifting the eccentric in this manner is almost precisely similar to that obtained by altering the position of the block in the link of an ordinary stationary link motion, the travel of the valve, and consequently the point of suppression being varied, but the lead being left unchanged. The expansive action obtained is, of course, less perfect than when a separate expansion valve is used, on account of the premature release and the compression; but it is nevertheless very good, and as Messrs. Marshall pay particular attention to the proper proportioning of the ports and the lap and lead of the valve, the arrangement is practically very effectual. Messrs. Marshall's engines had all steam-jacketted cylinders, and were of thoroughly good design and workmanship.

Next we had Messrs. Ruston, Proctor, and Co., of Lincoln, who showed two engines, one with a single cylinder, and the other with a pair. In both cases the cylinders were steam jacketted, and fitted with adjustable expansion valves, and both engines were provided with crossed-arm governors of the type which Mr. Jeremiah Head introduced to the notice of the Institution of Mechanical Engineers at their Middlesbrough meeting. There are two special details connected with Messrs. Ruston, Proctor, and Co.'s engines, which we should mention here, and these are illustrated on Pl. LXXV., Figs. 9 to 11. The first of these details is the expansion stay used for connecting the cylinder to the bracket carrying the crank shaft plummer block on the crank side of the engine. This stay (see Fig. 9) consists of a wrought-iron pipe attached to the plummer-block bracket and to the cylinder, and the interior of which is in free communication with the steam jacket of the latter. The tube being thus filled with steam expands and contracts with the boiler, and forms an efficient stay, without giving rise to undue strains resulting from unequal expansion. The stay is wrapped with non-conducting material which is sheathed in a brass casing, making a neat finish. The stay thus cleaded forms a convenient handrail, and a step by the side of the boiler gives ready access to all working parts.

Another feature of the engine is the stop-valve, which is illustrated in detail on Pl. LXXV., Figs. 10 and 11. This is simply a three-feather valve fitting a conical seat formed at the lower end of a brass bush, which passes up through the crown of the firebox casing into the cylinder casting, as shown in section in Fig. 11. The valve is actuated by a small crank at the end of the regulator rod, and the arrangement is a very simple one. It will be noticed that the bush into which the stop-valve fits, also contains the throttle valve, which is controlled, as we have said, by an approximate parabolic governor.

Messrs. Clayton and Shuttleworth who, for some 16 years past, have had a branch establishment at Vienna, and at whose works there, about 300 men are now employed, had a large show of portable engines at their stand next to Messrs. Ruston, Proctor, and Co.'s. The engines exhibited varied from 4 to 20 horse power, the engine of the latter size having two cylinders, and being fitted with link motion. It had also an extra large fixebox, and was altogether a sort of giant in its way. With the exception of this and a 16-horse engine, all the engines shown were provided with the wrought-iron flexible brackets for carrying the crankshaft plummer blocks, which the firm first adopted in 1871. In the engines to which these brackets are fitted, the strains due to the thrust and pull of the connecting rods are taken up by the bars which connect the crank shaft plummer blocks to the cylinders, or to the hind end of the engine. With one exception all Messrs. Clayton and Shuttleworth's engines were fitted with either separate expansion slides or with link motion, while all had steam jacketted cylinders. In most cases the hind axle was placed behind the firebox, and many of the engines were fitted with brakes, the brake blocks being fixed to a cross beam, and applied directly to the tyres of both the hind wheels. We like this plan better than using a separate brake wheel, and, moreover, as the blocks can be applied to both

the hind wheels, a greater holding power is obtained. The brakes in Messrs. Clayton and Shuttleworth's engines are applied by a screw, which is not rigidly attached to the boiler, but which when tightened up compresses a stiff helical spring. The use of this spring gives the arrangement a certain amount of elasticity, and enables the brake blocks to adjust themselves to the wheels, even if the latter should not be perfectly round. We notice also that Messrs. Clayton and Shuttleworth fitted to their engines a neat form of the "exhaust jet" feed heater, now used by so many makers. The workmanship of the engines is, we need scarcely say, excellent.

Adjoining Messrs. Clayton and Shuttleworth, Messrs. Hornsby and Son, of Grantham, showed three portable engines of 20, 8, and 6-horse power respectively. The two latter were of their ordinary single cylinder type, while the 20-horse had two cylinders, and was fitted with link motion. Messrs. Hornsby still adhere to their old plan of making their engines with very high firebox casings, the upper part of the latter thus forming a dome, and also a jacket to the cylinders, which are fixed within it. They are also one of the few firms which retain the round guide bars for the crossheads. The workmanship of the engines exhibited was good. At the next stand Messrs. Garrett and Sons, of Leiston, showed seven portable engines, these being all of their ordinary patterns, except that three of them, besides having the ordinary firedoor, were fitted below the latter with a large mouthpiece, also provided with a door, and intended for the introduction of straw, so as to adapt the engines for burning that fuel. The arrangement is one designed by Herr G. Mály; but we have had no means of judging of its efficiency. Messrs. Garrett are one of the very few English firms of any pretensions who do not yet steam-jacket their cylinders; we hope, however, to see them adopt the practice in time. Mr. Stephen Lewin, of Poole, and Messrs. W. Foster and Co., of Lincoln, are two other makers who exhibited engines with unjacketted cylinders, the former showing two engines, one with and one without a jacket, and the latter one engine of their ordinary type. Mr. Stephen Lewin, however, is we should add now steam jacketting all the engines made by him, so that the unjacketted engine at Vienna, formed an exception to his present regular practice. The engines last-mentioned complete our list of those shown by English makers.

Taken as a whole, the collection of engines sent to Vienna by British exhibitors was, as we have said, of a most creditable character, and one well calculated to show the progress which, during the past few years has been made in this branch of manufacturing engineering. With comparatively few exceptions, the English portable engines had steam-jacketted cylinders, a large number had separate expansion valves, and nearly all were fitted with some arrangement or other for heating the feed. And here we may remark that the plan of arranging the pump to deliver back into the feed tub, and heating the feed by the introduction of a jet of exhaust steam into the return stream of water, is that which appears to be now most widely adopted. If we are not mistaken, this form of exhaust jet heater was first introduced by Messrs. E. R. and F. Turner, of Ipswich, who, we believe, first showed it, in a somewhat crude form, at the Oxford meeting of the Royal Agricultural Society in 1870. Since then the plan has been adopted by other firms, and improved in its details, and a large proportion of the engines at Vienna were fitted with it, the arrangements applied by some of the makers being very neat. Altogether the plan is an improvement, in many respects, upon the old expedient of blowing a portion of the exhaust direct into the feed tub. Besides adopting the fuel-saving expedients, to which we have just referred, our English makers of portable engines have of late years made great progress in the matters of general design and workmanship, and, as far as the leading firms are concerned, there is now little to desire on these heads. In saying this, however, we must not be supposed to affirm that the portable engines now made in England are perfect, and, in fact, we hold no such opinion. We believe, that, as times goes on, and farmers and their employés become more and more accustomed to the use of steam power, the path will be opened for the employment of higher pressures of steam and higher piston speeds than are now used, the result being a material reduction in the weight

of engine required for a given power, as well as a further economy of fuel. Already the use of steam ploughing engines and agricultural locomotives is familiarising the farmer with higher speeds and pressures, and there are amongst our portable engine builders several who are fully alive to the advantages to be gained by such means, and who may be relied upon to introduce improved engines as soon as the demand for them arises.

French portable engine builders were very poorly represented at Vienna, there being, in fact, only three makers who exhibited, namely, MM. Albaret and Cie., of Liancourt (Oise), Del Ferdinand, of Vierzon-Forges (Cher), and M. J. Hermann-Lachapelle, of Paris. The first-named firm showed an engine with a very long boiler and circular firebox casing, the engine being fixed on the top of the boiler on a heavy cast-iron bedplate, on which is formed a slipper guide for the crosshead. The feed was supposed to be heated by the exhaust pipe being made to dip down with a bend into a tank at the side of the boiler. The whole engine was terribly rough, and the design generally bad. As for Del Ferdinand's engine, when we have said that it was somewhat better than Albaret's, we have bestowed on it all the praise it deserves. Like Albaret's, it had a round firebox, and a cast-iron bedplate on the boiler, while it was fitted with a feed heater, which was a bad imitation of Messrs. Brown and May's. The lagging of the cylinder of this engine was a curiosity of patchwork construction, and altogether the workmanship was very rough. The cleading plates of the cylinder, being painted imitation rosewood, make the appearance additionally aggravating.

The portable shown by M. J. Hermann-Lachapelle, was exhibited in the Machinery Hall, and it was altogether of a superior type to those sent by the other French makers. It was rated at 4-horse power, and had a large sized boiler with a steam dome over the firebox, a short pipe leading direct from this dome to the cylinder. The cylinder was mounted on a bedplate, having the crank shaft plummer blocks cast in one piece with it, this bedplate being bolted to the top of the boiler. The cylinder was steam-jacketted, and the steam circulated through the jacket on its way to the valve chest. The latter contained besides the ordinary slide valve, some arrangement of adjustable expansion valve apparently of the Farcot type. The feed was heated by a branch from the exhaust pipe being led into a small tank fixed at the side of the engine, the feed pump drawing its supply from this tank. The boiler was well cleaded, and the design and general finish of the engine were of a superior kind.

In the Machinery Hall also we found three other portable engines. One, in the Danish section, was an engine from Kockum's Engine Works, Malmo, of very fair workmanship, but with unjacketted cylinder, and similar in general design to those made in England some eight or ten years ago. The second engine in the Machinery Hall was from the Maschinenfabrik und Eisengiesserei Darmstadt, and was a somewhat similar engine to that last mentioned, it being of a pattern which we may term "old English," with unjacketted cylinder, but with a feed heater on the smoke-box. The workmanship of this engine was rough. The same makers also showed the handy little machine illustrated by us on Pl. CLXVI, Fig. 2. It is a combined steam winch and pump, intended for the use of contractors and others. The whole machine is carried on a rectangular frame of 7 in. by 3 in. channel iron. The boiler is placed in the centre of the frame; it is supported by wrought-iron brackets, and fixed from one side. The engine has a single cylinder, vertical and inverted, carried by light cast-iron angle framing, which is bolted to the boiler at its upper end. The winch, in the construction of which there is nothing calling for special mention, is placed on the front of the frame, and driven from the engine in the usual way. A small centrifugal pump is placed at the hinder end of the machine, and is driven by a strap from the flywheel of the engine, which has a turned rim for that purpose. The engine can of course be used to drive a circular saw or other machinery external to itself, when required, and is in every respect a handy affair. The whole is carried upon four wooden wheels, and fitted with shafts for horse transport. The boiler is intended to work at 90 lb. pressure.

In the Eastern Agricultural Hall were a few more portables, these completing the list of exhibits of this class at Vienna. Here we found an engine from Messrs. Lilpop, Rau, and Co., of Warsaw, which we must class as a portable, as it was mounted on wheels, but which was not of the ordinary type. The wheels in this case carry a wrought-iron frame, on which are mounted a vertical boiler and an inclined engine, the cylinder being placed at an angle of about 45°, and the crank shaft being at the highest point of the engine frame and next the boiler. The feed on its way to the boiler is forced through a pipe which traverses a cylindrical vessel through which the exhaust steam passes. This engine was not highly finished, but the workmanship looked sound and good, and there was no fault to find with the proportions. Close to this exhibit was shown a small and roughly finished portable from Vidat's István Gép-Gyára, Pesth, which requires no special notice. Close by, also, we found one of the few novelties in this department, namely, a rotary portable engine by Mr. William Dorning, of Polgardy, Hungary. Mr. Dorning puts his rotary engine on the top of an ordinary portable boiler; but we have no faith in the supposed advantages of the arrangement, and we fancy that the application of the Royal Agricultural Society's system of testing to such an engine would show some startling results.

In the Eastern Agricultural Hall also, Mr. J. D. Garrett, of Buckau, showed a couple of portables, one being a single cylinder and the other a double cylinder engine. Neither engines had a steam jacket, but both were fitted with an arrangement for heating the feed by waste steam conducted through a branch pipe from the exhaust. The workmanship of the engines was very good and the proportions substantial.

On the opposite side of the hall Herr G. Sigl, of Vienna and Wiener-Neustadt, exhibited two portable engines which showed a higher class of workmanship than those of most other Continental exhibitors. Both engines were fitted with expansion valves, that of one engine being under the control of the governor, which is placed on the crank shaft, and acts on an expansion eccentric. The cylinders of Herr Sigl's engine were, we regretted to notice, not steam jacketted, and the only arrangement for heating the feed consisted of a branch from the exhaust, which could be put in communication with the feed tub. Lastly, we noticed in this hall two portables (8 and 10 horse power) from the Fürstlich Liechtenstein'sche Maschinenfabrik und Eisengiesserei, Adamsthal, near Brünn, these being engines of a very ordinary type with unjacketted cylinders, the larger one having a feed heater on the side of the boiler, in which the feed is heated by the exhaust steam.

We have now completed our list of the portable engines at Vienna, and it will have been seen that in this department the show made by Continental builders was as inferior as that of the English firms was good. The were no American portables, and, with the exception of the one from Darmstadt, and the two from Mr. J. D. Garrett of Buckau, none from German makers, while Belgium was entirely unrepresented in this class of machinery. It is curious also, considering the ease with which portable engines are transported, that France should show three such engines only. The deduction to be drawn from this state of affairs is either that Continental builders are not desirous of competing with English makers in the Eastern markets, or that they feel themselves at present incapable of doing so, the latter conclusion being, we believe, the truth. With such large numbers of English-built engines annually being sent to the Continent, it is, however, inevitable that the present extraordinary specimens of foreign portables should be succeeded by better types, and, therefore, although our English firms may be well satisfied with the display they made at Vienna, it by no means follows that they will have it all their own way in the future, They have, however, got an excellent start, and they may be fairly trusted to make the best of it.

Steam Pumps.

The immense number of variations which can be made in the arrangement of a very small number of parts is in no kind of machinery to be more clearly seen than in steam pumps, and every possible arrangement seemed to be represented in the Machinery Hall at Vienna. There were vertical and

horizontal, single and double-acting pumps, pumps that seemed to be nothing but two cylinders and a piston rod, and pumps that had as much gear as a Corliss engine, brass valves and india-rubber valves, slide valves and piston valves, valves with gear, and valves entirely self-acting. In attempting to give some idea of all these varieties as they were seen at Vienna we shall commence at the western end of the Machinery Hall, with the American exhibits. Here were to be found only two exhibitors of steam pumps, the Norwalk Iron Works (whose engine has been formerly referred to), and Carr, of New York. The first-named firm sent one of Earle's pumps, a type pretty well known in England, and still better on the Continent, where Decker Brothers and Co. (Canstatt) have the sole right of manufacture. It is a horizontal double-acting pump without rotary motion. The steam valve is a piston valve, and is worked from the piston rod by an arm having at its extremity an eye encircling the valve rod, and striking at each end of the stroke a collar (buffered with india-rubber) on the valve spindle, and thus moving the valve. Mr. Carr exhibited two Selden pumps, strongly made, but without any attempt at finish. The largest was intended specially for mines. It was a horizontal pump without rotary motion, in which the piston rod worked two single-acting force pumps on the same centre line, one behind the other. The steam valves were worked by tappets from the piston itself.

The English pump makers were pretty well represented, and appeared to be the only ones who have taken up to any large extent self-acting valves—for out of the English section there was scarcely a pump to be seen in which the valves of the steam cylinder were not driven by a tappet, cam, eccentric, or other apparatus, while in one instance, at least, even the pump valves were also driven by gear. The principal of these automatic pumps are Hayward Tyler, and Co.'s patent "Universal" pump, Tangye Brothers and Holman's "Special" pump, and Clarkson's "Excelsior" pump, the latter exhibited by Mr. McNicol, of Glasgow. The construction of these is pretty well known in England, but for the sake of comparison with foreign constructions, it may be as well to say a few words about them here. The "Universal" pump can certainly claim to be the simplest machine of its kind shown in the Exhibition It is of the ordinary double-acting unrotative type, and has no visible valve chest or valve gear at all. The steam pipe enters the side of the cylinder in the centre of its length, and the admission valve is a piston valve working automatically in the centre of the steam piston, the latter being made of great depth, so that it may always cover the opening of the steam pipe. The valve is so arranged that the engine can be started freely from any position without moving it by hand (which indeed it is impossible to do), by merely opening the steam cock. The valves used in the pump are, for cold water and for ordinary pressures, india-rubber ball valves. Six or seven Universal" pumps were exhibited, one or two being generally at work.

Messrs. Tangye had at work a "Special" pump with a steam cylinder 14 in. in diameter and water cylinder 12 in. in diameter, with a stroke of 2 ft. The steam valve is a double-ended piston valve placed above the cylinder, its motion being determined automatically by two small valves placed one at each end of the cylinder. A handle is provided to start the piston valve when necessary. The pump valves, which are illustrated on Pl. LXXI., Fig. 13, are those patented by Mr. Holman, the peculiarity of them being that they have no central seating or wings, so that the least possible resistance or obstruction is offered to the free passage of the liquid through the seatings. Mr. Holman uses mineralised junction india-rubber rings as valve seatings, one portion of each ring being rendered hard for the purpose of keeping it true and holding it firmly in position, whilst the other portion is comparatively soft, to insure a silent and sound seating to the valve. The flexible seatings are secured in their places by means of screwed rings, affording every facility for examination and renewal. The valve is made parabolic in form, so that the least possible resistance is offered to the passage of the water. A tubular buffer is placed above each valve, the upper end of this buffer embracing the guide rod, and the lower end the boss of the valve. The valve is thus prevented from rising too high, and at the same time leakage through its centre is

obviated. The tube further acts as a spring in assisting the valve to close quickly for the return stroke. Although these pumps have not the extreme simplicity of the last-mentioned kind, they possess certain advantages of their own, and an enormous number of them are now in use.

Mr. McNicol's pumps (Mr. John Clarkson's patent "Excelsior," manufactured by Messrs. Clarkson Brothers, of Glasgow and Maryhill) in general appearance resemble the "Specials," they also belonging to the large class in which the motion of the steam-distributing valve or valves is made quite automatic, all eccentrics, tappets, or valve gear of any kind being dispensed with. The means by which the valve is made to move are here very simple, and will be understood on reference to the engravings of the pump given on Pl. LXXVII. The valve is cylindrical, and capable of an endlong motion without rotation, steam-tight, in a cylindrical box placed on the top of the steam cylinder. By means of closed ends, and two transverse partitions, the valve is divided into three separate compartments. The steam ports of the cylinder terminate, or rather commence, in openings into the bottom of the valve chamber, while the steam pipe terminates in two openings in the top of the same chamber. The end compartments of the valve have holes top and bottom so arranged that in certain positions they allow free communication between the cylinder port and the steam pipe; the steam on being admitted to the cylinder, therefore, passes through these compartments. The middle compartment is open on the under side, and serves just the same purpose as the hollow under an ordinary slide valve, making the communication between the steam and exhaust ports. The steam piston is double-ended, the space between the two ends being always in free communication with the exhaust by means of a hole in the cylinder wall. The clear distance between what are virtually the two pistons must therefore be equal to the stroke of the engine plus the width of the hole just mentioned. Two small holes, about $\frac{1}{8}$ in. diameter, are also made in the side of the cylinder, and passages from these communicate with the two ends of the valve chamber, each hole communicating with the end which is furthest from it. These holes are so placed that when the piston is at or near either end of its stroke, one of them opens into the space between the pistons (and consequently into the exhaust), and the other into the cylinder beyond one of the pistons.

We can now describe the action of the valve. When it is in the position shown, the steam, passing downwards through the right-hand compartment of the valve, forces the piston from right to left, the steam on the left of the piston exhausting freely through the centre of the valve. As soon as the right-hand piston passes the small hole, however, steam rushes through it, and throws the valve suddenly over from left to right (for the other end of the valve is in communication with the exhaust) and so admits fresh steam against the left-hand piston, and allows that which has just been doing the work to be discharged. At the end of the stroke the piston is again in the position shown in the engraving, the valve is thrown over from right to left, and so the operations go on *ad infinitum*.

The object of the small brass handle seen in the cross section is to start the engine if the valves should happen to have stopped in the wrong place when the pump last ceased working. The construction of the pump is very simple; it is fitted with solid brass valves, both for suction and delivery. There are three principal castings in the machine, the cylinder with the valve chest and ports being one, the pump and its valve seats another, and a distance piece, which also forms the inner covers of the cylinder and pump, the third. The cylinder and pump have each a foot cast upon them, upon which the machine rests. The pistons, valves, &c., are all so arranged that they can be easily got at, and the small holes through which the steam passes to move the valve can be readily cleaned if they should be clogged up from any cause. Altogether the pump seems entitled to claim all the advantages in simplicity which belong to its type, but like them it is necessarily a somewhat wasteful steam user, as no expansion can be used in the cylinder. Three of Clarkson's pumps were exhibited at Vienna one being always shown at work.

Messrs. Alexander Wilson and Company showed a number of their well-known vertical donkey pumps, in which a short shaft with a flywheel lies

across the top of the cylinder. The steam valve is driven by a pin from the back end of the shaft. The two cylinders and the frame which connects them are all cast in one piece, which is not the case with any of the before-mentioned pumps, and the pumps are both strong and simple in construction, In the single-acting pumps the steam piston and the pump plunger are made in one piece of brass, the upper part of the plunger forming the piston rod of the steam cylinder; the double-acting pumps have steel piston rods. Messrs. Hathorn, Davis, Campbell, and Davey had a vertical pump with rotary motion and double connecting rod, and arranged in a way which can scarcely be commended when it would have been so easy to make it simpler. Messrs. Warner and Sons had two small Ramsbottom's pumps, one combined with a vertical boiler, about which there is nothing special to be said. In the English section of the Machinery Hall there only remains now to be mentioned two pumps, which, although not intended for boiler feeding as is the case with most of the pumps hitherto mentioned, must yet be included here. Of these, the first is Bolton and Imray's "Helical" pump, which was exhibited by Brotherhood and Hardingham, and worked direct by one of their three-cylinder engines already described by us. This pump which is illustrated on Pl. LXXVI., is beginning now to be used as a circulating pump for surface condensers, and for this purpose, as well as many others, its simplicity and general construction would seem much to recommend it. Its great advantage is that it does not change either the form or direction of the stream of water passing through it, but maintains it of exactly the same section throughout. Its efficiency is said to be high, and repeated experiments seem to have proved, whatever may be the reason of it, that its circumferential velocity for a given lift is only about half that required for an ordinary centrifugal pump.

The other exhibit just referred to was an admirably finished centrifugal pumping engine shown by Messrs. John and Henry Gwynne, of the Hammersmith Iron Works. This pumping engine which we illustrate on Pl. LXXVI., Fig. 1, drew the water from a tank, and after raising it 15 ft. high discharged it into the same reservoir. The engine is of the usual type made by this firm, and the pump is of their latest pattern. The engine has a steam cylinder $6\frac{1}{4}$ in. diameter and $6\frac{1}{2}$ in. stroke; the speed when throwing 700 gallons per minute 15 ft. high is only 210 revolutions per minute. The disc of the pump is 42 in. in diameter. There are many of these pumping engines working direct from the crank shaft at 60 ft. lifts. The side of casing in which the disc revolves can be taken off, and the disc examined or removed for repairs if necessary without disturbing the rest of the pump or engine. Messrs. J. and H. Gwynne had numerous other exhibits of centrifugal pumping machinery, among which we noticed several novelties. Thus there was a pumping engine to throw 3,000 gallons per minute 30 ft. high, several of a new class of pump for drainage and irrigation, pumps on two wheels, for farm use, and arranged to allow the suction pipes to swivel to any angle so that the pipes could go down the side of a river bank, pumps mounted on galvanized iron carriages to be drawn by horses or bullocks, and a swivelling stationary pump, the suction and discharge pipes of which could be placed at any angle. The workmanship and material were of Messrs. J. and H. Gwynne's usual first-class character.

In the English boiler house three of the smallest possible pumps—one by Hayward, Tyler, and Co., one by Brown Brothers and Co., and a "Paragon," by Brotherhood and Hardingham—sufficed to feed a long row of boilers. The American boiler was fed by a small Earle's pump, made by the Norwalk Iron Works.

The only pump exhibited in the French section of the Machinery Hall was by Hermann-Lachapelle, of Paris, whose neat combined vertical engines and boilers we have before alluded to. The pump is intended for raising large quantities of water to a considerable height. It has two single-acting force-pumps with large trunk plungers, one placed on each side of a cast-iron standard, and each worked by a crank on the end of a shaft passing through the standard. The top of the standard carries two plummer blocks for the driving shaft, which drives the crank shaft below it by spur gearing about 4 to 1. The whole machine is well made, and the different working parts

easily accessible. The Fives Lille Cie. had, in the French boiler house, quite a large horizontal engine with two flywheels on its shaft, working behind it two single-acting pumps in much the same way as in the Selden pumps before mentioned. These pumps have air vessels both on the suction and delivery, and their suction valves are opened by means of an eccentric on the crank shaft. The three last-named engines, although well made, seem to us considerably larger and more heavy than there is any occasion for. There did not seem any reason why much simpler and smaller pumps should not do all the necessary work, and yet not occupy more than one-quarter of the space taken up by the above mentioned arrangement.

Herr Schmidt, of Zurich, was the only Swiss exhibitor of pumps in the Machinery Hall, the arrangement he adopts, which is very ingenious, being illustrated on Pl. LXXV., Figs. 6 to 8. The steam and water cylinders are precisely alike, with the exception of differences in the proportions of the ports and passages, and are placed horizontally at opposite ends of the machine, the crank shaft lying between them. The two piston rods are connected to the same crank pin, and on each end of the crank shaft is a small flywheel. The cylinders are necessarily oscillating, but the trunnions have not (as is common in such engines) anything to do with the steam admission; they are simply solid pins. The oscillation of the cylinder regulates the steam admission in the following manner:—The ports are underneath the cylinder, and what would in ordinary engines be the valve face, instead of being flat, is made part of the surface of a cylinder of which the centre is the centre of the trunnions—that is, the centre of oscillation. This face works on another correspondingly shaped, fixed face underneath it. One of the features of the engine is that the trunnions do not work in bearings fixed to the bedplate, but in the ends of levers, of which the fulcra are as near as possible to the centre of the crank shaft. The ends of these levers can be drawn downwards by means of screws, and in this manner the two steam faces are kept tight. Similarly arranged faces to those of the steam cylinder form the valve faces of the water cylinder. In these engines the steam is certainly not economically used, but this is not always the principal desideratum in steam pumps, and those just described are certainly extremely simple in their construction as well as absolutely noiseless.

In the German section the principal exhibitors of pumps were Decker Brothers and Co., of Canstatt (Würtemberg), formerly referred to. They are, as we have have before stated, the holders of the European patent rights for Earle's pumps, and all their machines are made on that pattern. They had a number of different sizes exhibited in the Machinery Hall, as well as two very large ones in their pumping station, of which we have already given an account (*vide* page 46 *ante*). In order to show the adaptability of these pumps for mines and tunnels, they had a small one working by compressed air, another one (with valve specially arranged for the purpose) compressing the air to 1½ atmospheres, and storing it in a wrought-iron receiver. Messrs. Decker Brothers have, as we have already noticed, introduced a novelty in the shape of a patent condenser for steam pumps, which is intended not so much to economise the steam (which, however, it must necessarily do to some extent), as to save the trouble and expense attendant in some situations on long exhaust pipes. The steam is passed into the suction pipe of the pump, and brought well into contact with the water by a number of rings in the pipe, placed something like a Venetian blind if the latter were bent into a circular shape. There is no separate condenser, and the condensed steam mixes with the water, the pump itself acting as the air pump. In the larger sizes of Decker's pumps the piston rods are guided in the frame between the two cylinders.

Messrs. Lossen and Schaeffer, of Darmstadt, exhibited several of their "Universal" steam pumps, of which two were at work, one in the Hall, and one outside, pumping water 100 ft. high. These pumps are in construction very much the same as Decker's, almost the only external difference being that small spiral springs are substituted for the india-rubber buffers of the slide spindle; the pump valves are, however, differently arranged. We

cannot say much for their workmanship, which is not up to the mark; but the pumps are simple, and the valves can be easily got at. In most cases it will be necessary to break at least one pipe joint to take the slide-case cover off, a defect which ought to be remedied. They are made of many types, to work with variable expansion, high and low pressure, condensation, &c. The Neptun Continental Wasserworks Actien Gesellschaft (Berlin), and the Berliner Union Actien Gesellschaft, each exhibited pumps with self-acting valves, which can differ very little, if at all, from Tangye's. The Berliner Union's pump, instead of resting on two brackets, one under each cylinder, rests on one only, placed underneath the space between the two cylinders, which, to give a larger foot, is made somewhat longer than usual. The Neptune Company has also several vertical force pumps driven by gearing, but there is nothing about them which calls for remark.

Messrs. Brodnitz and Seydel, of Berlin, had several well-made vertical inverted donkey pumps, one of which is illustrated on Pl. LXXV., Figs. 4 and 5. It is a double-acting pump, arranged on the well known "bucket and plunger" principle, the area of the plunger being equal to one-half of the area of the barrel. Only two valves, therefore, are necessary—one foot valve, and one valve in the bucket; both are ordinary conical gun-metal valves, and they can be readily got at through suitable doors. The pump bucket is fitted with a packing gland on its under side, which can be tightened up through the door which gives access to the foot valve. The arrangement is very neat and handy. The connecting rod is made an open frame, completely encircling the cylinder, upon the upper cover of which are placed the crank shaft plummer blocks. The slide valve is worked by an eccentric placed between the flywheel and the bearing. The flywheel is placed on the front of the machine, on the side that is furthest from the wall or other surface to which it is attached. There seems no reason why the pump should not attain a good efficiency, as well as show itself an economical steam-user. The pumps shown by Messrs. Brodnitz and Seydel were well and substantially made.

In the Austrian section Herr Wannieck, of Brünn, showed a very neat vertical, inverted, single acting donkey pump, of which views are given on Pl. LXXVII., Figs. 7 to 9. As will be seen from these views it has a steam cylinder 6½ in. diameter by 10 in. stroke, working a single-acting pump with a plunger 4 in. diameter. The plunger, it will be seen, is connected directly with the piston of the steam cylinder, as in the patterns of some English makers with which we are familiar, and the effective area of the bottom of the piston, the side on which the steam presses when it is only raising the plunger, is thus reduced. The upper end of the connecting rod works on a crosshead pin, projecting from the middle of the plunger, this pin being guided between flat bars. The flywheel shaft passes through an eye cast below the pump, which serves, without brasses, as a bearing; a similar plain bearing being also cast in the wall plate of the machine, and the flywheel being placed between the two bearings. The disc in which the crank pin is fixed is arranged eccentically to the shaft, and being encircled with a strap it serves as the eccentric for working the slide valve, the rod of which passes freely upwards through a hole in the crosshead pin. There are three main castings in the pump; the wall plate, which contains the lower bearing, and to which the other two castings are bolted—the cylinder and slide chest—and the pump and valve boxes. The valves are brass, of the ordinary conical description, working in seats of exceptional length. A cast-iron air vessel is placed directly above the delivery valve, and access to the valves is obtained by removing this vessel. The pump is well and substantially made, although a good deal heavier than those of the same power which we are accustomed to see in this country.

The Fürst. Johann Liechtenstein'sche Maschinen Fabrik in Adamsthal, had two horizontal engines arranged to work separate pumps through the ordinary triangular rocking frames. Knaust, of Vienna, had some ordinary double-acting vertical pumps driven by straps. The Maschinenbau Anstalt, F. J. Müller, Prague, had a horizontal steam pump, of which the cylinder works a crank shaft with a double flywheel in the usual way, and also works a pump

behind; while the same firm also showed a small donkey engine, in which the rectilinear motion is converted into the rotary by a slotted crosshead, in a brass in which the crankpin can work. The Brünner Zuckerformen Eisenblechwaaren und Maschinen Fabriks Gesellschafft, Brünn, showed a small donkey engine very like Wannieck's but without the disc utilised as eccentric, and also a horizontal pump driven by pulleys through spur gearing. And Brüder Noback, und Fritze, Prague, exhibited a similar but more simple pump in the Eastern Agricultural Hall; of none of these any detailed mention is necessary.

In the Austrian boiler house two vertical donkey engines of Sigl's were used, both as feed pumps, and to move the mechanical fire-bars which he used in his boilers. They were well made, but presented no novelty to us except that the piston rod crosshead was guided (the shaft lying underneath the pump) between cast-iron faces in the framing, instead of on an outside column, as is commonly the case.

The boilers in the German boiler house were fed by four donkey engines, two neat single-acting verticals, with shaft underneath, by the Carlshütte Actien Gesellschaft, one single-acting pump, by Brodnitz and Seydel, and one Earle's pump, by Dietrich, of Reichshofen. In the Belgian boiler house, Bede and Cie. (Société Houget-Teston, Verviers), had a vertical donkey with two pumping cylinders. The crank shaft is supported by, and crosses the top of, a heavy cylindrical pillar frame, and one pump is worked below the steam cylinder direct from the piston rod, while the other stands on the other side of this pillar, and is worked from a pin in the flywheel. In the Swiss boiler house there was a somewhat similarly arranged pump by the firm Gebrüder Sulzer, Winterthur, but in this case the pumps were worked off a second shaft geared from the engine shaft.

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Miscellaneous Details.

We have now to describe a few isolated engine details, which could scarcely be classed under any of the foregoing divisions, and which are yet worthy of notice here. The first of these is the balanced slide valve, designed by Mr. William Dawes and Mr. Henry Holt, of Leeds, which was exhibited in the British section, and which we illustrate on Pl. LXXVII., Figs. 15 and 16.

In designing this valve Messrs. Dawes and Holt have aimed at producing a valve and relief frame which shall be practically in one piece, or in other words, an automatically adjustable solid. This end they accomplish as follows:—A plate or thin sheet of steel is riveted or screwed on to the valve back, and likewise to the relief frame, a few inches being left free all round, as shown in the section, Fig. 15. This elastic valve and frame together are made about $\frac{1}{16}$ in. deeper than the steam chest between the cylinder face and the surfaced portion of interior of steam-chest cover, consequently when the cover joint is screwed home, the free part of the steel plate or diaphragm is set down or compressed this $\frac{1}{16}$ in. This compression it retains (after the manner of a spring) until such time as it is required to be given out to compensate for wear, which has been found practically, in some hundreds of instances, to be three or four years. This compression or deflection of the diaphragm is, in fact, chiefly necessary until the faces have become polished, after which the wear is inappreciable.

When the relative areas of the free part of diaphragm and the back face of frame are properly proportioned, the relief frame holds itself against the chest cover face without the aid of springs, the latter being not used in this balanced valve. In some cases scarcely any compression has been found necessary, but should the relief frame blow off the face, which is an indication that either the back face is of insufficient area, or that there is no compression on the diaphragm, and that steam gets between the faces into the relief chamber before the frame has time to get into the face, this can easily be remedied by letting up, and thus giving more compression to the diaphragm. When properly proportioned these balanced valves are as light to handle with steam on as off, and they are stated never to have been known to leak or

waste steam, when the workmanship is even moderately good; should this be defective, a few week's work makes them tight.

The relief chamber is in most cases open to the engine room, so that no leakage can occur without being perceived. The valve has, however, been found so free from leakage, that many engineers prefer making small holes through from the relief chamber into the condenser or exhaust passages. In the engravings on Pl. LXXVII., the studs which connect the diaphragm to the valve, are shown pierced by small holes for this purpose.

We have next to speak of the Allen governor, shown by Messrs. Whitley Partners, of Leeds, who had a large and varied collection of exhibits in the British department of the Machinery Hall. This governor is illustrated in Figs. 6, 7, 8, and 9, Pl. LXXI.

In these figures, A denotes a cylindrical drum provided on its inner periphery with a series of flanges or ribs *a a* arranged at or about equal distances apart. This drum is mounted on, and so as to turn on, a shaft *b*, there being another shaft *c* to which the drum is fixed. The shaft *b* extends into the drum from one head *d*, the shaft c being extended from the other head *e* as shown. To the shaft *b* and within the drum, a series of paddles or flat wings *g g* are fastened, each of these paddles being made to radiate from the shaft in manner shown in fig. 8. The two shafts are supported in bearings *h h* in a standard B, erected on a valve case C as shown. On the shaft *c* there is fixed a volute scroll or fusee D, having a chain or rope *k* fastened at one end to its periphery and extended partially around to a weight or series of weights *l*. A small gear wheel or pinion *m* fixed on the shaft *c* engages with a toothed sector *n* fixed on a shaft *o* passing through the valve case C, through a stuffing box *p*, and thence into the induct E. An arm *q*, carrying a friction wheel *r*, projects from that part of the shaft *o* which is within the induct E of the valve case and enters a slot or passage r^1 made in the shank *s* that connects two valves *t u*. These valves are arranged as shown, with ports or openings *v v*, made in the opposite sides of the tubular induct E projected within the case C, the said induct being closed at its inner end. An eduction pipe F leads out of the lower part of the case C.

If now we suppose a driving belt from a pulley or drum on a shaft of a steam engine to run upon a pulley or wheel *w* fixed on the shaft *b*, the series of paddles or floats *g* will be put in revolution within the case A. This case is filled with water or with a fluid which by the action of the paddles or floats will be put in revolution and thrown against the flanges or ribs *a* of the case A, thereby causing the said case to revolve in the same direction. As a consequence the pinion *m* will be revolved so as to put the tooth sector *n* in movement, so as to turn the shaft *o*, and thereby effect a movement of the valves or what may be termed the double balanced valve of the induction pipe E of the valve case C. The rotary movement of the case A will be resisted by the weight suspended from the scroll or fusee D, which as it revolves will increase the leverage of the weight on the shaft of the case.

An arm projecting from the shaft *c*, and provided with an adjustable weight is not so effective as the scroll or fusee with its line and weight, for with the former the effect of the weight is diminished as the arm moves out of a horizontal position, but with the fusee or scroll the effect or resistance of the weight constantly increases as its rope is wound up by the scroll or fusee. Thus it will be seen that with the scroll or fusee there is an element in action not incident to the arm and weight as ordinarily used, such element and the functions performed by it being specially useful in connexion with the governor as described. By having the valves operated by the arm *q* applied to their connexion *s*, there will be no pressure on the valves such as would result were their stem extended through a stuffing box and out of the case C. Consequently the compound valve becomes a "balanced valve" easily put in operation by the governor.

Applying the fusee or scroll with its suspended weight directly to the shaft *c* is far preferable to applying it, or an arm with an adjustable weight thereon, to the shaft *o*, for in the latter case the weight has to be very materially increased to produce the necessary result, as it has to operate

through the sector lever and its pinion, and consequently has all the leverage of such to overcome in order to move the case A. The governor above described is a very powerful one and acts promptly.

Another exhibit showed by Messrs. Whitley Partners, which we have to include in the present division is Berryman's steam trap, illustrated on Pl. LXXVII., Figs. 12 to 14. As will be seen by Fig. 14 the apparatus consists of a large hollow ball connected to the steam pipe to be drained by two horizontal pipes, these latter pipes being of such length as to possess sufficient elasticity to allow the ball to move up and down through a short range. The weight of the ball is supported on V-centres which rest on the shorter arm of a weighted lever as shown, the other end of this lever being coupled by a rod to the arm of a stop-cock fitted to a third pipe leading from the lowest point of the pipe to be drained.

The action of the apparatus is very simple. As water collects in the steam pipe it gradually fills the hollow ball until at length the latter overbalances the weight at the other end of the lever by which it is supported; and by descending opens the discharge cock and allows the water to escape. This being done the ball is emptied, or partially emptied, and being overbalanced by the loaded lever, rises again and closes the stop-cock. The stop-cock used is of peculiar construction, and it is shown in the sections Figs. 12 and 13. From these views it will be seen that the water entering the cock on one side of the plug passes upwards and downwards through recesses formed in the latter, these recesses communicating, when the plug is turned, with openings in the case on the opposite side to that at which the water entered. By this arrangement the plug is approximately balanced, and it is found to move very easily and keep tight without trouble.

Messrs. Whitley Partners were also the exhibitors of another steam-trap, namely, Vaughan's, illustrated in Pl. LXXVI., Figs. 7 and 8. This trap or rather water escape valve, belongs to the class in which the opening for discharge is caused by the cooling and consequent contraction of a tube B in which the water accumulates. In using the apparatus, steam should first be blown through it to allow the tube B to acquire the temperature of the steam, and by means of the hand wheel I and lock nut G the valve D should then be closed and secured. As the water collects in the tube B the latter will of course cool and contract, thus giving an opening for discharge between its lower end and the valve D. Discharge valves have long been made on this principle, but the arrangement adopted by Mr. Vaughan is particularly neat and compact.

Conclusion.

In concluding this section of our report, we propose to point out some broad characteristics of the Continental engines, and make some general remarks on them. It is fair to start by premising that neither England nor Austria can be fairly judged simply by taking an average of the engines they exhibited at Vienna. For England, it will have been noticed that many of our best engine makers were conspicuous by their absence, and that we had not a single specimen of a really large factory engine exhibited, while in Austria a disproportionate number of very inferior makers exhibited, very naturally, as an advertisement, as it was so easy and cheap for them to do so. The engines from America, too, were by no means fairly representative of that country, or at all equal, either in workmanship or in originality of design, to the American machinery which they drove. There were only four of them altogether, and two of these were small common verticals. It may be taken that the engines from Germany, France, Belgium, and Switzerland pretty fairly represented the better class of engineers of those countries, and in speaking of Austrian engines we will not include in comparison some four or five which were obviously a long way below the genera laverage of the Austrian makers. Some of the smaller nations, as Denmark and Sweden, although they had exhibits, can scarcely be said to have been "represented" in any proper sense, while Spain and Portugal sent nothing whatever. In comparing Continental work with English, therefore,

it must be understood that we do not so much refer to the English engines at Vienna, as to the average run of good English work generally.

Through the whole Machinery Hall one broad distinction was observable between English and Continental makers, a distinction which determines to a very great extent the character of the machines made, and which—it may be remarked—extends itself to the locomotives as well as the stationary engines. The English engineer, while he wishes economy of steam, thinks more of simplicity and cheapness, unlikeliness of needing repairs, and ease of making them; the Continental engineer, on the other hand, while not forgetful of these latter points is willing, to a far greater extent than is the case with us, to sacrifice them to securing a high steam efficiency. Thus in the English section, we found almost every engine with a steam jacket—although there was at least one important exception to this rule—and an adjustable expansion slide valve, but only very few in which the cut-off was controlled by the governor; while even in these few only the ordinary slide expansion was used, and the connexion with the governor was of the simplest possible. In the Continental engines, however—that is, in those constructed by makers of the same standing in their own countries as the English makers in Great Britain—the great majority had their cut-off valves controlled by the governor, and of these a very great number had some special valves and gear arranged for an instantaneous cut-off. It is not our object just now to discuss the relative merits of Corliss valves, double-beat valves, and slides, but one point in relation to them seems very much forgotten, and it may be well to point it out here. One of the principal objects of using Corliss or other instantaneously closing valves, is certainly to obtain a sharp cut-off corner in the indicator card. At the same time few engineers would recommend any such gear in any engine but one intended to cut off early, certainly not to have a normal cut off later than $\frac{1}{6}$th to $\frac{1}{8}$th of the stroke, in many cases of course not so late. At this period of the stroke, however, the actual speed of the piston is but slow (even when the engine is running fast), and as a matter of fact an engine with properly arranged expansion slide, worked on the back of the main slide by an eccentric opposite the crank, will give a corner in the diagram as sharp as the most efficient spring gear which we have seen, if the cut-off be not later than that which we have mentioned. The extreme importance which is attached to an economical use of the steam on the Continent was almost ludicrously shown in one or two engines which the makers had thought proper to fit up with elaborate valve gear while as yet they had not attained sufficient experience in their profession to design a crosshead or proportion a connecting rod. Of course, besides giving the sharp cut-off, the Corliss valves and gear have the advantage of requiring less power to drive them than ordinary slides; but this is a matter which we need not enter into here.

We examined with great interest the exhibits in Group XXVI. (Education) which had been sent by various technical schools and colleges in Austria and Germany. The teaching apparatus, and also the curriculum, seemed most complete, and as if the latter embraced every point (by no means excluding as some people imagine, practical work, but, on the contrary, laying much stress on it) necessary to make a young engineer's education complete. We even contrasted sadly in our minds the English system—or absence of system—of training engineers, with the completeness of the Continental educational apparatus for the same purpose. Judging from results, however—and this is certainly the most, or only, satisfactory criterion—the difference is not at all what one would suppose; indeed the advantage—we can say it after an impartial examination of the engines in the Machinery Hall—still lies with us. It is unquestionable that the most ingenious devices in the Exhibition (the Bede, Berchtold, Dautzenberg, or Radinger valve gears, for example) all come from Continental engineers. But whatever deficiencies English engineers have, they are certainly not deficient in mechanical ingenuity, and the fact that they have not produced such things (which we must not be supposed to dispraise) must be laid at the door, not of our defective educational arrangements, but of the fact that such machines would

find no market with us, and that, therefore, there is no inducement to design them. These things, too, owe much more to the high degree of mechanical ability possessed by the individual inventors than to the educational system under which they had been trained. Polytechnic schools can neither make nor mar born mechanicians—such men will always come to the front—but their influence ought to be seen in the general designing and proportioning of the machines made by their scholars in after life. Not one English engineeer out of twenty has ever been taught how to proportion a crank, or find the diameter of a connecting rod, and too many apprentices have grown up into men (at least one has had the impertinence even to write books) cherishing the fond idea that they were somehow connected with the "depth of cup of gland," if not with the length of the boiler tubes. They have been left to pick up their theoretical knowledge in a haphazard way, and unless they are enthusiasts in their profession, possibly they never pick up any at all. But just these things the technical schools teach, and, therefore, just in these points we should expect *à priori* to find Continental engineers ahead of our own. Whatever may be the reason of it, however—a matter we cannot go into here—it is a fact patent to any one who may take the trouble to examine for himself, that really more obvious blunders in proportioning are made by Austrians and Germans than by ourselves. In one of design they are ahead of us; they have adopted the "Corliss" system of bedplate (or some analogous design) to a much greater extent than it is used in this country, and we should think it probable that their example may after this be more largely followed among us. There can be no doubt that this form of bedplate is preferable in all cases where it is not necessary, on account of sudden shocks, as in rolling mills, &c., or for any other reason, to give the engine more weight than is necessary for strength or stiffness. With the Corliss bedplate a simple form of guide supersedes the crosshead and guide bars, which are clung to with so much tenacity by many English engineers. Apart from this matter of design, however, and looking to the proportioning of the different parts of the engines, there is much room for improvement, and even engineers of reputation have made some bad mistakes. These arise from several causes, all of which a proper education should have provided against, but principally from three, viz.: ignorance of the right way in which to proportion different parts to resist the stresses to which they are subjected, ignorance of the best proportions for rubbing surfaces, and ignorance of the proper factors of safety to use in different cases. We must not be understood as accusing Continental engineers *en masse* of failing under these three heads, but these are just the points in which one would expect them to excel, and as a matter of fact they do the opposite. Under the first head comes the proportioning a crank in such a way as is shown in the sketch, Fig. 17, Pl. LXXVII., a thing that is done by a number of good makers, who can scarcely be supposed desirous of wilfully wasting metal. We need scarcely point that if A D and B C are to be, as is, of course the case, straight lines, then if A B is equal to half C D, each side is tangential to a parabola of which the other side is the centre, and the strength of the lever (supposing it of uniform thickness) is as nearly uniform as it can be without resorting to a curved outline,—C D, however, being its weakest part. If A B is greater than half C D, the latter still remains the weakest cross section, and, therefore, the additional metal is thrown away. Under this head there also came a number of double eyes, and in some cases a whole connecting rod, of which the diameters and other dimensions seemed to have been guessed, and guessed badly. The second head is less important, but covers some very deficient piston rod head guides. The third head is specially noticeable where there are long rods in compression, either in the valve gear or in other places. Some of these are far too light; there are few practical engineers but will bear us out in saying that a factor of from 16 to 20 is often by no means more than sufficient to insure stiffness in such rods.

The ingenuity which has been so successful in inventing valve motions, has not always been accompanied by a proportionate amount of common sense in working out their details, and particularly is this shown in an almost

touching belief in the absolute rigidity of wrought iron, and an apparent idea that brackets, levers, and pins may be to any extent overhung, and yet work accurately. This certainly received most striking illustration in the locomotives—where we noticed in one case that the distance from the face of a wheel to the outside of the outside eccentric was no less than 19 in. or about 26 in. from the nearest end of the axle bearing—but it is also sufficiently evident in the stationary engines. For example, in one of the Corliss engines (which presented several good points in design, and was superior to a good many of its neighbours in workmanship), the lever which, worked by the governor, absolutely controls the cut off, was arranged as in the sketch Fig. 18, Pl. LXXVII., its boss being about 6 in. long, and the pin quite small. As a very natural consequence, the catches *a* and *b*—after the engine had been working about a month, already shook (or to use a more expressive word "woggled") to an extent that may alter the cut-off quite an inch of the stroke. There were cases innumerable in which a little management might have saved such an arrangement as this; and we even noticed cases in which washers or collars, like *a*, Fig. 19, Pl. LXXVII., had been inserted with absolutely no necessity whatever, and no reason except to make the connecting rod overhang, and others where the lever boss had been by choice made as at *b*, when it would have been quite easy, and both cheaper and better, to have made the web flush with the end of it.

It is worth while to note that the practice of having the main bearing brasses adjustable in two directions, which is making considerable progress in England, is very general on the Continent, nearly all engines making any pretence to excellence being fitted in that way. Almost without exception, the connecting rods are made with strap ends, or, at least, made to tighten with a gib and cotter. The various modifications of the old-fashioned arrangements are, some of them, very neat and commendable, as will be seen in our detailed illustrations of the engines. It is somewhat to be wondered at that not one single maker exhibiting at Vienna hit on the idea, comparatively common with us, of forging the piston rod head in one piece with the rod. Even in the one or two cases in which the head was fitted with bolts it was made separately, and keyed on to the rod. Although the key way does not reduce the area of the rod below that at the bottom of the thread behind the piston, there still seems no sufficient reason why it should be cut when forging the head in one with the rod is such a simple operation.

The workmanship shown in the Continental engines was, on the whole, good, but there was certainly often a want of solidity and of finish about it which is difficult to describe, but which becomes intelligible enough after examining such an engine as Galloway's or Messrs. J. and H. Gwynne's. Some of the Austrian engines, as we have already said, were very bad, though no worse than we should expect to see in some English machines at a similar exhibition in England. The castings, however, could scarcely rank along with the machine work of the engines; they were in most cases much inferior to it. Besides that they were rough and unfinished looking, the mistake was made over and over again of making the fillets in the corners far too small, which gave one an unpleasant feeling that they might crack at any moment.

It is very greatly to be regretted that such an opportunity as that which was offered at Vienna was allowed to pass by without advantage being taken of it to carry out a series of comprehensive trials of engines and boilers. The neglect of such an opportunity is a matter for which the Exhibition authorities will ever be blamed, as by taking advantage of it they might have added most materially to our knowledge of steam engine performance, and furnished data of great and permanent value. It is in fact not too much to say that such engine and boiler trials, if carried out as they should have been, would have done more to make the Vienna Exhibition memorable than anything that could have been devised.

In conclusion we may state that we give amongst the Plates a couple of tables containing the chief dimensions and general particulars of all the

leading stationary engines exhibited at Vienna. In compiling these Tables—which, for convenience, have been marked as Pl. LXXVIII. and LXXIX.,—no pains have been spared to render them complete and trustworthy, and they will, we believe, be of considerable interest to a great number of our readers.

BOILERS.

At no previous Exhibition were there so many different boilers to be seen at work together as there were at Vienna. This circumstance arose from the fact that at Vienna each country was allowed to supply the steam for driving its own machinery from boilers exhibited by its own manufacturers, an arrangement which it will be remembered did not hold good at Paris in 1867, where all the steam generators employed in the service of the Exhibition were of French make, excepting only those in the English department.

The total number of boilers exhibited at Vienna was thirty-three, of which twenty-six were to be seen at work, and in this number the boilers of semi-fixed engines are not included. There were, further, many parts and fittings of boilers, such as patent grates, furnace doors, feedwater heaters, &c., several of which were interesting, and deserve special attention.

Of the boilers actually shown at work—

America exhibited	-	1
England „	-	6
France „	-	1
Belgium „	-	2
Switzerland „	-	1
Germany „	-	6
Austria „	-	9

Three sets, or six boilers of the Austrian collection, were employed in driving the three pairs of pumping engines which we shall describe in their proper section, while nearly all the others exhibited were employed in the service of the Machinery Hall itself, and were to be seen in the boiler houses outside, and at the back of this latter building.

The American boiler exhibited was manufactured by Pitkin, Brothers, and Co., of Hartford, Connecticut, and was lent by them to the National Commission, in order to furnish the steam required for their section of the Machinery Hall. It was a quite simple, multitubular, cylindrical boiler, lying horizontally. The furnace was situated underneath the front end of the barrel, the flames passed from thence underneath the bottom, and returned through the tubes to the front end, from whence they were conducted directly up the chimney. The front end was closed by a smokebox door, by means of which access was gained to clean the tubes. There was nothing in this boiler which calls for further notice.

The collection in and around the English house comprised two of Galloway's well-known boilers, two of Messrs. Daniel Adamson & Co.'s, one of Howard's "patent safety boilers," one by Cater and Walker, of Southwark, and one of Sinclair's patent, exhibited by John McNicol, of Glasgow, while in addition there were three "patent economisers" or feedwater heaters exhibited respectively by Joseph Twibill, of Manchester, by Edward Green and Son, of Manchester, and by Andrew Bell, of Haslingden.

Taking these exhibits in the above order, we have to speak first of Messrs. W. and J. Galloway and Sons, who showed two boilers each 24 ft. long by 7 ft. in diameter. These boilers were, as we have said, of Messrs. Galloway's well-known pattern, each boiler having two furnace flues 2 ft. 10 in. in diameter, and these two flues being united to a single elliptical flue (5 ft. 9 in. wide, by about 3 ft. high) which extended to the back of the boiler. Through this elliptical flue passed vertically twenty-four Galloway tubes, these tubes not

only promoting circulation, and affording most efficient heating surface, but also strengthening the elliptical flue, and enabling it to resist collapse. The elliptical flue of each of these Galloway's boilers was bulged inwards at the sides in six places so as to form so called "pockets," which not only give additional heating surface but aid in mixing the gases proceeding from the two furnaces. The fittings of these Galloway's boilers were all complete and of good patterns, and the workmanship was throughout excellent.

Next we come to the boilers by Messrs. Adamson & Co. of Hyde Junction, near Manchester. These boilers were, as will be seen from the illustrations, (Plate XXXV., Figs. 1 to 3,) of the double-flued Lancashire type, and they were exactly alike, except that one was made entirely of steel, while the other was of wrought-iron, with the exception of two rings of each flue at the furnace end, these lengths being made of steel.

The boilers are each 24 ft. long by 7 ft. in diameter, and each contains two flues 2 ft. 9½ in. for the greater part of their length, this diameter, however, being reduced to 2 ft. 4 in. at the back end by the introduction of tapered rings, as shown in the plan. In both boilers the flues are made with Mr. Adamson's well-known flanged joint, the flue rings being flanged outwards at each end, and the rivets joining the adjacent flanges passing also through an intermediate ring, which assists in giving rigidity. Each of the steel rings at the furnace end has a single longitudinal joint arranged below the level of the firebars, and in the case of the wrought-iron boiler, all the remaining lengths of the flues have the longitudinal joints welded up; there being in this instance no rivetted seams in the flues exposed to the action of the fire. Each flue is intersected by eight water tubes P, arranged vertically and diagonally, as shown, these tubes being welded in place. Each end of each boiler is made in a single plate, the back plates being flanged over to join the shell, as shown, while at the front ends the connexion between the end plate and shell is made by an external welded ring of angle iron. The end plates are sufficiently stiffened by gusset stays.

The setting and fittings of the boilers are arranged according to the latest and best practice. From the flues the gases pass under the boiler to the front end, and then back along the sides to the chimney, the draught being regulated by a pair of "butterfly" dampers Q Q, which can be turned on their axes by means of handles O O at the front of the boiler, these handles being fixed on shafts which extend for the length of the boiler, and which are connected with the axes of the dampers by bevel gear, as shown. The feedwater is admitted at F, it passing into an internal pipe which extends a considerable distance along the boiler a few inches below the water line. By this arrangement the feedwater is heated before it mixes with the water in the boiler. At G is a scum-cock, and at H a blow-off cock, these both communicating with a line of pipes for discharging the water blown off. Each boiler is also provided with two gauge glass fittings, two of Cowburn's dead weight safety valves, steam stop valve, and manhole doors at D and E.

To those who are familiar with the work turned out by Messrs. Daniel Adamson & Co., it will seem unnecessary to add that the boilers were a first-rate job. The rivet holes were all drilled after the plates had been put together, the plate edges were all planed, and the general finish was excellent throughout. We may mention here, also, that Messrs. Adamson likewise exhibited a portion of a flue constructed on Mr. Adamson's system, which had been indented—by blows delivered from the outside—to the extent of 5 in. or 6 in. Even under this treatment, however, the joints had remained uninjured. This length of flue was an admirable specimen of plate flanging and welding.

The next boiler on the list is that of Messrs. Howard, of Bedford, which was of the well-known water-tube type made by that firm. It consisted of twenty tubes each about 9 in. in diameter and 9 ft. long, arranged in five horizontal and four vertical rows. Each tube is formed of wrought iron welded, and the front ends are closed by screw caps: the rear ends of each vertical row debouch into a vertical tube, while the front ends of the lowest horizontal row are fastened into the feed-water pipe, and thus all the tubes are put in communication with one another. All the tubes are inclined in position; the

direction of slant running upwards from the front to the rear end. The greater part of the top, and a smaller part of the second horizontal rows are always filled with steam when the boiler is at work, thus forming a sort of drier, and perhaps even a superheater, which is very useful in doing away with the priming, which would otherwise ensue from the want of an easy transit from the heating surface to the steam reservoir, which latter is a horizontal tube communicating by means of smaller pipes with each of the four vertical rows. The furnace is situated underneath the boiler, and the flame is carefully guided so as to impinge on every part of the tube surface by means of a simple system of baffle plates. Access is gained to the boiler for cleaning purposes by means of a smokebox door situated in the front of the setting.

The next and last of the English boilers shown at actual work was one contributed by Messrs. Cater and Walker; this being of the same type as the set manufactured by the same makers for the Albert Hall. In form it is cylindrical, the barrel being 14 feet long by 7 feet in diameter, and it is moreover, multitubular, the arrangement of the tubes being, however, quite different to that usually adopted. The fire-bars, which are 7 ft. 6 in. long, are underneath the front end, and the flames, &c., pass along the bottom of the boiler, and then rise up into a sort of uptake formed in the body of the barrel, this uptake being 1 ft. 9 in. wide at the bottom and rising 2 ft. 8 in. into the boiler. From the uptake the gases pass through a set of inclined brass tubes, 4 in. in diameter, to the front end, where they find themselves in a second uptake or smokebox, 1 ft. 10 in. wide, and 3 ft. high. A second set of straight tubes conducts the hot gases back again to the rear, whence they pass directly up the chimney. The two uptakes are stayed by means of water tubes, and the front one is provided with a smokebox door, by means of which access is gained to the tubes for cleaning purposes. The steam is collected in a large cylindrical steam dome or steam drum.

Outside the house there was another English boiler contributed by McNicol. It was a water-tube boiler similar in principle to that of Messrs. Howard, but differing from it in details and dimensions. The tubes were much smaller in diameter, and were fastened by being expanded into the transverse and feed-water pipes. This boiler was not shown at work, and there is nothing further of interest to say about it.

The account of this part of the English exhibition will be completed further on, by the description of the three economisers, all of which are apparatus for saving fuel by causing the waste gases from a boiler to impinge, on their way to the chimney, against a number of tubes filled with the feedwater. The two of Messrs. Twibill and Messrs. Green are the same in general arrangement, although they differ in constructive detail, each consisting of long tubes set vertically in the path of the gases. In both cases scrapers are provided to free the outside of each tube from the accumulation of dirt and soot, and these scrapers are caused to move up and down by means of chains coiled round wheels, which latter take their motion from shafting driven by a strap and pulley. The third feed-water heater, exhibited by Mr. Andrew Bell, consists of coiled iron tubes, which contain the water; the scraper in this case is mounted on a revolving spindle, and travels gradually all over the coil. We shall, however, as we have said, describe these economisers later on, and it is therefore unnecessary that we should say more respecting them here.

France.

Leaving England and travelling east we next came to France, which was represented by one specimen at work, contributed by Fives Lille. This boiler belonged to a type which has found great favour in France, and is known in that country by the name of "*chaudière à bouilleurs.*" In England it is commonly called the "elephant" or "French" boiler. It consists of a main horizontal cylinder, underneath which are two smaller ones, which are called heaters or "bouilleurs," and are connected with the main boiler by means of vertical tubes of large diameter. The front ends of these heaters are closed by mud-hole doors, for the purpose of cleaning out the sediment, most of which collects there. The furnace is underneath the heaters, and the gases

are conducted all along and around them and the main boiler by means of side and central exterior flues, there being no internal tubes or flues whatever.

Although not shown at work, there were also exhibited in the French section, examples of the Belleville boiler, constructed by Messrs. Belleville & Co. of St. Denis, near Paris. This boiler has been so extensively introduced in France, particularly on board vessels of the navy, that it appears to us to merit a special description, although we are far from regarding it with such favour as it has received in many quarters. Two of the Belleville boilers were shown in the Machinery Hall, one being of similar construction, although not identical dimensions as that we illustrate (Plate XXXVI.), while the other was of a smaller class. The boiler shown in our illustration is one of those constructed by Messrs. Belleville & Co. for the dispatch boat "L'Actif," and it shows clearly the numerous peculiarities of detail which distinguish M. Belleville's system.

The boilers of "L'Actif," which supply steam to engines of 400 I.H.P., are three in number, and they are placed side by side in a line extending across the vessel, forward of the engine room. The three boilers are exactly similar and a description of the port boiler, shown by Figs. 1 and 2 of the engravings, Plate XXXVI., will therefore serve for all. The boiler is composed of three principal parts, namely, 1st, the steam generator proper, consisting of the tubes and their connecting boxes; 2nd, of the casing formed of plates, angle irons, and brickwork; 3rd, of the necessary fittings, of which we shall give a description presently. Each steam generator proper consists of eleven "elements," each composed of twelve tubes A, disposed one above the other, and coupled at their alternate ends by connecting boxes E, as shown in Fig. 1. The eleven elements are placed side by side at a short distance apart, all the upper tubes and all the lower tubes being respectively in the same horizontal planes. The upper tubes are all connected with a transverse steam collecting tube C, whilst a similar transverse tube B, connects all the lower tubes and serves to distribute the feed water to the various elements. Above the upper collecting pipe C, and parallel to it, is placed the round pipe D, which serves to lead off the steam to the engine. The pipes C and D are connected by five vertical pipes of different sizes, the centre one being smaller than those to the right and left of it, while these again are smaller than those which are near the extremities of the tubes. This arrangement is adopted to equalise the draught of steam from the various sections.

The tubes of which the boiler is composed are of wrought iron, and are 6 ft. $10\frac{5}{8}$ in. long by $2\frac{3}{4}$ in. in diameter inside, and 0·24 in. thick. The connecting boxes, into which the ends of the tubes are screwed, are of malleable cast iron, and each is furnished with a couple of mud-holes opposite the ends of the tubes as shown in Fig. 11. All the elements are connected together at the front by the upper and lower connecting tubes and at the back by a wrought-iron frame and tie-bolts, distance pieces being provided to maintain the proper intervals between the elements. The whole is thus bound together into a compact mass, and at the same time the tubes are left free to expand or contract longitudinally. The tubes are each formed in a single piece, except the upper and lower tubes of each element, which are each made in two pieces connected by a coupling. This arrangement, which is adopted for the purpose of facilitating the putting together and taking to pieces of the elements, is clearly shown by the detailed view Fig. 11. The whole of the boiler proper is enclosed in a casing composed of wrought-iron plates and angle irons, lined with fire-bricks, the construction and form of this casing, together with the arrangement of the fire-grate, &c., being so clearly shown in our illustrations that no description of them will be necessary. In the upper part of the casing, and above the steam generator proper, are a number of plates, termed by M. Belleville *brisé flammes*, these being so placed that the intervals between them are less on the side next the chimney than towards the other side, so that they equalise the draught between the elements.

We have now to speak of the boiler fittings, to which we have already referred. Some of these, as, for instance, the stop valves and the safety valves, are of the ordinary kind, and require no description; but there are others, shown by the detail figures in our engraving, which possess special features. The first of these is the apparatus for regulating the water level,

shown by Figs. 3, 4, 5, and 6. This apparatus consists of a wrought-iron cylinder fixed vertically in front of the boiler, as shown in Figs. 1 and 2. This cylinder, marked A in the detail views, is connected at the lower end with the lower transverse feed pipe by the short wide tube C, Fig. 4, whilst its upper end is placed in communication with the upper steam-collecting pipe by the tube B, Fig. 5. The feed is regulated by the cock D, communicating with the pipe E, and which is actuated by a float within the cylinder A, as shown in Fig. 4. I and H, Fig. 3, are respectively a pressure gauge and water gauge of the ordinary kinds, whilst J is a cock for blowing out the apparatus when necessary. The height at which the water level is maintained by this apparatus is capable of variation by adjusting the counterweight on the lever connected with the spindle of the cock D.

The "separator" shown by Figs. 7, 8, 9, and 10, is placed between the boiler and the engines, and serves to separate from the steam any water carried over by it. This separator consists of a wrought-iron cylindrical vessel A, Fig. 8, placed in a vertical position, and divided into two parts by a partition. The cylinder is furnished with a cast-iron cover, having inlet and outlet pipes attached to it, these pipes communicating with opposite sides of the partition. Besides these pipes there are also the two tubes or passages G, cast in one piece with the cover, and which serve to place the two chambers in communication, as shown. The steam entering the apparatus through the pipe E is projected downwards, and is thus caused to deposit some of the water carried over by it at the bottom of the chamber R. From this chamber it passes through the pipes G, into the second chamber, where it is again projected downwards, and thus caused to deposit its water more completely. From the second chamber the dried steam passes off to the engines through the pipe H. The partition between the two chambers is pierced by holes at its lower part, and the water which accumulates in the bottom of the cylinder is discharged by means of a self-acting overflow cock, the arrangement of which is shown clearly in Figs. 7, 8, and 10. The separator is provided with a glass water gauge, and with a cock for discharging the accumulated water by hand in the event of the self-acting arrangement getting out of order. There is also provided a cock I, which serves to discharge any excess of steam from the boilers, and which is intended to be used to prevent the loss of water which takes place when the safety valves blow off.

Of the remaining views Fig. 12 shows the arrangement of relief valves for discharging any excess of water delivering by the feed pumps, the upper chamber of this valve casing communicating with two pipes, each furnished with cocks. One of these pipes serves to discharge the excess of water overboard when the boilers are being worked with sea water, while the other, which is used when the boilers are supplied with water from the surface-condensers, serves to conduct the excess to a tank, of which we shall speak presently.

Fig. 13 shows the arrangement of feed water tanks used by M. Belleville in connexion with his boiler. When the boiler is worked with fresh water supplied by the surface condensers, the feed tank A receives the water raised by the air pump D, while it is also in communication by the pipe M, with the reserve tank B. The feed pumps, the valve box of which is situated at C, draw from the tank A, the feed water not required by the boiler passing back into this tank past the relief valves, which are situated at R. The arrangement shown in Fig. 13 enables the boilers to be readily employed for furnishing a quantity of distilled water in the event of the supply running short. When this distilling operation is to be performed the cock is closed and the reserve tank B filled with sea water. The cock H is also closed, and that marked O opened, so that the feed pumps are made to draw sea water from the tank B. At the same time by opening the cock S and shutting the cock T, the overflow from the relief valves is caused to flow into the tank B instead of the tank A. Things being thus arranged, it follows that salt water will be supplied to the boilers while the distilled water arising from the condensation of the steam in the condensers will collect in the tank A, from which it may be led through the pipe P to any desirable storing vessels.

While this process of distillation is going on the water which accumulates in the "separator," already described, is brackish, and the ordinary self-acting discharging arrangement is therefore thrown out of gear, and the salt water discharged into the sea by means of a cock regulated by hand. When a sufficient amount of distilled water has been collected the parts can of course be readily restored to their normal position, and all that then remains to be done is to free the boilers of the salt water contained in them by means of judicious blowing off. The whole arrangement is an exceedingly convenient one. In conclusion, we subjoin the principal dimensions of the boilers of "L'Actif," these being as follows:—

Number of boilers	3	Total grate surface	75·34 sq. ft.
Height of boilers	7 ft. 7 in.	„ heating surface	2347 „
Length	8 „ 0½ „	Load on safety valves	113 lb. per sq. in.
Width across the three boilers	14 „ 8 „	Height of chimney above level of grate	34 ft. 9 in.
Total number of tubes	396	Diameter of chimney	4 ft.
Interior diameter of tubes	2¾ in.		
Length of tubes	6 ft. 10⅝ in.		

Belgium.

In the Belgian boiler house we found but two boilers, one of these being one of Belleville's boilers just described, and the other being a horizontal multitubular cylindrical boiler, constructed by the Société John Cockerill, of Seraing. This latter boiler was made for internal firing, and required no brick setting; it was, however, of an ordinary type, and requires no detailed description.

Switzerland.

The Swiss boiler was one exhibited by the celebrated house of Sulzer Brothers, of Winterthur. So excellent, both in design and execution, were all the exhibits of this firm, that it is some satisfaction to know that their chief engineer, Mr. Brown, is an Englishman. The boiler was employed to supply the necessary steam for the whole machinery in the Swiss section at Vienna. The views on Plate XXXIX., Figs. 1 to 4, include a longitudinal section of the boiler and setting; a sectional plan through *e*, *f*; a cross section through *c*, *d*; and a cross section through *g*, *h*, showing the feed heater.

The boiler proper differs little from an ordinary double-flued Cornish boiler, with a couple of Galloway tubes in each flue. The flue is strengthened by Mr. Adamson's plan of flanging the plates outwards, a system which also has the advantage of removing the rivets from the direct action of the flame. An expedient worth notice is adopted to increase the circulation of the water over the flues, and so increase their evaporative efficiency, and prevent scale. It is shown in the two upper views, and consists in placing curved plate shields over the upper half of the flues at a distance of about 3 in. from them. An opening, several inches wide, is left along the shield right over the top of the flue, and in this way it is expected that a rapid circulation will be kept up over the surface of the flues. The principal feature in the boiler setting is the care which has been taken to avoid, as far as possible, resting the boiler upon, or embedding it in brickwork. It will be seen that its whole weight rests upon three cast-iron brackets, and also that the brickwork which divides the flues in the setting is made to rest upon iron plates instead of being, as is too frequently the case, supported by the boiler.

The arrangements for heating the feed water are very complete; indeed the feed-heating surface is nearly as great as that of the boiler itself. The products of combustion, when passing over the top of the boiler, are made also to surround two long cylindrical vessels, 19½ in. in diameter, and 27 ft. 10 in. long, and further on their way to the chimney to pass through the tubulous water heater shown. The water is heated to some extent by the exhaust steam of the donkey feed pumps before it enters the feed heater at all, and it then passes continuously through the whole feed-heating system in the opposite direction to that in which the gases are moving, an arrangement which is of course the best adapted for securing the maximum transference of heat from the gases to the water. Side doors are provided for the purpose of cleaning the

tubulous section of the feed heater, and a door in the brickwork also provides sufficient access to the upper part of the boiler, the lower flues being reached from the front end.

The boiler is 6 ft. 3⅝ in. in diameter, and 20 ft. 2 in. long. It contains a heating surface of 498·3 square feet (46·3 square metres), and the feed heaters contain altogether a surface of 396 square feet (36·8 square metres), making in all 894 square feet. It is built for a working pressure of 75 lb. per square inch above the atmosphere. The fire-grate is constructed on Mehl's patent, the peculiarity of which is that the bars are unusually short, deep, and narrow, with very narrow air spaces between them.

Germany.

Passing on eastwards, we next came to the German shed, in and around which eight boilers were shown, five of these being at work, while there was one additional boiler exhibited in the Machinery Hall itself. Of this number four specimens were sent from the Actien Gesellschaft der Hollerschen, Carlshütte, near Rendsburg, two of them on J. C. C. Meyn's patent, being kept at work, a third larger one of Meyn's being in the Machinery Hall, while the fourth was lying outside the boiler house. These boilers are vertical, and of a very novel construction, and it will be seen from the experiments of which the results are given below, that they possess very considerable steaming powers.

Meyn's boiler consists externally of two cylinders, of which the upper is the smaller. The furnace is half internal and half external, and it will be seen from the engravings (Plate XXXVI., Figs. 14 to 18,) that it requires but little building. It is made in this way because sufficient grate surface cannot be obtained on this system with an entirely internal furnace. The grate is 6 ft. 8 in. by 2 ft. 4 in., and has a surface therefore of 15·4 square feet. It has no bridge, but communicates directly through a short vertical flue, of which the upper opening is 2 ft. 1 in. diameter, with a central combustion chamber. This chamber is 5 ft. 7½ in. diameter inside and 2 ft. 8 in. deep at the sides. Its roof is somewhat dished, and is stayed to the upper part of the boiler by ties as shown. The combustion chamber is traversed by 76 flattened vertical water tubes, which form one of the principal features in the boiler, and Fig. 15 shows their position in the cross section. They are wrought-iron welded tubes, with horizontal channels across their sides, the arrangement of which is shown to a larger scale in Figs. 17 and 18. Through these tubes the water circulates from the lower part of the boiler, and between them the flame must pass. From the roof of the combustion chamber a double ring of tubes leads up to the upper part of the lower shell, the upper cylindrical shell being of such a diameter that it stands inside these rings of tubes. This upper shell is inclosed in a smokebox of the same diameter as the lower shell, and made of sheet iron. The ordinary water level is two-thirds up the height of the upper tubes, as shown in the engraving. The upper shell therefore serves as a steam dome of large capacity, and has apparently been really effectual in preventing priming. The steam is led away from the top of the boiler through a pipe which forms a triple ring round it in the smokebox before it is allowed to go into the air.

These boilers are machine-rivetted throughout, and if their rivetting is at all as good as that of some specimens (cut in half and planed) exhibited by the Carlshütte Company, it must be unusually excellent. The company manufacture their own rivets, and make them, we noticed, with exceptionally large heads. The horizontal seams in the boiler are all single-rivetted butt joints and the vertical seams plain single-rivetted joints, but these latter would be better arranged to break joint than placed as at present in one continuous line down the side of the boiler. Proper attention has been paid to making the different parts easily accessible for cleaning and repairs, and they are more easily to be got at than is generally the case in similar somewhat complicated boilers. The usual working pressure is 60 lb. per square inch above atmospheric pressure. Meyn's boilers are used, among other things, for being heated by the flame and gases from puddling furnaces, but under those circumstances there is in general such a super-abundance of heat that it can seldom be necessary to use such a complicated boiler in order to economise it.

The principal dimensions of the two Meyn's boilers exhibited at work at Vienna are as follows:—

	ft.	in.
Length of lower shell	8	4
Diameter „	6	3
Length of upper shell	6	5
Diameter „	4	4
Total height of boiler	14	9
Number of flat water tubes	74	
Total surface of tubes	96 sq. ft.	
Number of round tubes	66	
Diameter of tubes	2.48 in.	
Surface of tubes (to water line)	80 sq. ft.	
Total surface in boiler to water-line	275 „	
Total surface in boiler above water-line	155 „	
Total heating surface in boiler	430 „ (40 sq. m.)	
Length of grate	6 ft. 8 in.	
Width of „	2 „ 4 „	
Grate surface	15·4 sq. ft.	

A number of experiments have been made with Meyn's boiler by engineers and others who use it, and from those published we select the following, which seem to have been made with care and completeness at the Essen cast steel works, in Rhenish Prussia. The boiler tested was one with 34·5 square metres (371 square feet) total heating surface, of which 10·9 square metres (117 square feet) was above the water-line. The grate surface was 1·54 square metres (16·57 square feet). We have reduced (see Table on next page) the evaporation given to the corresponding evaporation from and at 100 deg. centigrade (212 Fahr.), which affords a better means of comparison than evaporation from 0 deg. and 100 deg., which is the form given in the original table. The analysis of the fuel used was as follows:—

Carbon	81·34
Hydrogen uncombined	3·45
Hydrogen in combination	0·74
Oxygen and nitrogen	5·89
Sulphur	0·64
Water	2·00
Ash	5·94
	100·00

One pound of the coal to which the above analysis refers, can evaporate theoretically 14·35 lbs. of water from and at 212 deg. Fahr.

The temperature of the gases in the chimney in the immediate neighbourhood of the smokebox was 215 deg. to 240 deg. centigrade (419 deg. to 464 deg. Fahr.), and the ashes were from 14 to 15 per cent. of the weight of the fuel. It is due to the inventor to say that these experiments were made by the boiler users at his request, quite independently of him or of the boiler-makers, and we see no reason to doubt their accuracy. The results which we have arranged in the table on the next page are not those most favourable to the boiler, but those which seemed on the whole the most complete. With a better fuel, a better evaporation should, and no doubt would, be obtained.

The boiler seems to be very free from priming, which is only what its exceptionally large steam room would lead us to expect. The weakest point about it will probably be the upper ends of the round flame tubes, which are only a small distance above the water level. We have always found that tubes, the fastening of which is exposed on one side to flame, and on the other to very wet steam, are very apt to give trouble by leaking. We may add that Meyn's boilers are in great favour at Krupp's works at Essen, where ten of them, each of 40 horse power, are employed to drive his 50-ton hammer. Twenty-five of them were at work there in 1873, and twenty-four more were in process of erection.

TABLE showing RESULTS obtained with MEYN'S HIGH-PRESSURE BOILER.

No. of Experiment.	Kilos. of Water evaporated from and at 100 deg. C. by 1 kilo. of Coal.*	Coal consumed per minute.	Coal consumed per minute.	Water evaporated per minute.	Water evaporated per minute.	Kilos. of Coal used per square metre of heating surface per hour.	Kilos. of Water evaporated per square metre of heating surface per hour.	Pounds of Coal used per square foot heating surface per hour.	Pounds of Water evaporated per square foot heating surface per hour.	Kilos. of Coal per square metre of grate surface per hour.	Pounds of Coal per square foot grate surface per hour.	Percentage of useful effect of coal to total theoretical heat of its combustion.
		kilos.	lbs.	kilos.	lbs.							
1	9·198	2·15	4·73	16·61	36·54	3·7	29·0	·754	5·91	83·7	17·07	64·1
2	8·865	2·44	5·36	18·17	39·97	4·2	31·7	·856	6·46	95·0	19·38	61·8
3	8·211	2·80	6·16	19·32	42·50	4·9	33·7	·999	6·87	109·1	22·25	57·2
4	8·020	2·94	6·46	19·84	43·64	5·1	34·6	1·040	7·05	114·7	23·39	55·9
5	7·746	3·27	7·19	21·30	46·86	5·7	37·2	1·162	7·58	127·5	26·01	53·9
6	7·413	4·28	9·41	26·80	58·96	7·5	46·8	1·530	9·54	166·9	34·04	51·8

* This column is, of course, the same as if pounds were substituted for kilogrammes.

The next boilers which we have to notice as being at work in the German boiler house are those constructed by Messrs. Paucksch and Freund, of Landsberg, upon a system which they have patented, and which possesses in arrangement several points of interest

We owe to a pamphlet published by the patentees a maxim which may be freely rendered in English "*the durability of a boiler is a function of its accessibility*," and that there is much truth in this no one who has had anything to do with the practical management of boilers will deny. In designing the boiler under notice, the accessibility of the different parts has been a thing as much aimed at as the economy of fuel or anything else of the kind, and, it must be said, with considerable success. In Plate XXXV., Fig. 4, is a half plan and half sectional plan, Fig. 5 a longitudinal section, and Fig. 6 a half cross section and half front elevation with section across the ashpit. The two boilers are precisely similar in construction, and are set in brickwork side by side. Each one is 7 ft. 6 in. in diameter, and 17 ft. long, and contains 92 tubes $3\frac{1}{2}$ in. in diameter, arranged in two nests in the manner shown in the cross section. The furnace is entirely external to the boiler, and the principal peculiarity about it is that it is covered with a firebrick arch, which prevents the flame beating directly on the first ring of plates which, under ordinary circumstances, are exposed to greater danger of burning than any others. In boilers where rapid steaming is not a primary object, this shelter for the first two rings of rivetting is certainly advantageous. The brick arch is 4 in. thick and extends forward 5 ft. of the length of the boiler ; it is just clear of the boiler shell in the centre, and of course the distance between them increases rapidly towards the sides. The gate is 5 ft. 4 in. square, the bars being in two lengths ; there are two firedoors, but the grate itself is all in one, the division between the doors being only in the front. The products of combustion return through the tubes to the front of the boiler, and then back round its sides through flues which open into a large cross flue behind. To the front of the boiler is fixed a sediment tube, 15 in. in diameter, from the bottom of which the boiler can be blown off. On each boiler is an ordinary dome 2 ft. 10 in. in diameter, and from the top of these domes the steam is carried through copper pipes to a wrought-iron cylindrical superheater, 2 ft. 2 in. in diameter and 14 ft. long, which lies along the top of the cross flue just mentioned. No angle iron is used in the boilers or superheater, the end plates, dome, &c., all being

flanged. The holes in the tube plates are bored slightly taper, and the ends of the tubes (which are thickened up), are also made slightly taper and expanded into their seats by a screw mandril. One of the special features of the boiler is the arrangement of the tubes: they are made in two sets or nests, with a clear space of 12 in. between them, so that a man can quite easily and comfortably stand between them or (on account of the much larger space allowed at the bottom) kneel down to work, and so get at any one for cleaning, &c., with the greatest facility. The inventors state it as their experience (these boilers, it is right to say, have had some years' trial in actual work, and there are now 600 or 700 in use all over Germany), that owing to the great distance between the furnace and the tubes, and the consequent change in the nature of the flame from "Stichflamme" or striking-flames to mere burning gas, scale will not form on the tubes, but only on the shell of the boiler, from which it can most easily be removed. No doubt scale would more easily form on the latter, and with moderately good water none might even touch the tubes, but however this may be, we have seldom seen a boiler from which all such accumulation could more easily be removed. A large manhole in the top of the boiler allows access to the inside, and the other fittings, gauge, float, &c., are shown on the drawings and present nothing special for remark. In front of each set of tubes is a cast-iron door, (see elevation in Fig. 6, Plate XXXV.,) by opening which the tubes can easily be cleaned while the boiler is at work, and through which, as well as from the back, access can be had to the side flues.

These boilers were brought out in 1869, and two years afterwards some interesting experiments were made with them, on the request of the inventors, by Messrs. C. Schwanitz and Franz Serger, engineers in Berlin. The experiments were made at sugar works in Gutschdorf, in Silesia, with a Paucksch and Freund's boiler which had been about a year at work, and a newer Lancashire boiler of the ordinary construction. The following is an abstract of the report made at the time by these engineers.

The boilers were a Lancashire boiler of 6 ft. 4 in. in diameter and 30 ft. long, with two internal furnaces each 2 ft. 6 in. diameter a total heating surface of 797·7 square feet, and a total grate surface of 25 square feet; and a Paucksch and Freund boiler of 6 ft. diameter and 18 ft. long, with 96 tubes 2½ in. in diameter, a total heating surface of 1,355 square feet, and a total grate surface of 25 square feet.

The water passed to each of the boilers was measured by one of Siemens and Halske's patent water meters. The fuel used was Waldenberg (Lower Silesia) small coal, No. 3, a very inferior fuel. The feed-water had a temperature of 134 deg. Fahr., and the steam pressure was kept throughout at 60 lbs. per square inch. The duration of the experiments was ten hours, and during this time there was used in each boiler 5,200 lbs. of coal. The water level was noted at the commencement of the experiment, and was the same at the end; the index of the water meter was also carefully observed, and the following were the results.

The Cornish boiler had, with the 5,200 lbs. of coal, evaporated 31,600 lbs. of water, or with 1 lb. of coal 6·08 lbs. of water. The multitubular boiler with the same fuel had evaporated 42,400 lbs. of water or with 1 lb. of coal, 8·15 lbs. of water The principal results are shown more clearly in the following short Table:—

—	Heating Surface.	Grate Surface.	Coal burnt per hour.	Coal burnt per foot grate surface per hour.	Water evaporated per hour.	Water evaporated from 134° under 60 lb. pressure per pound Coal.	Water evaporated from and at 212° per pound Coal.	Water evaporated per foot heating surface per hour.	Ratio of grate to heating surface.
			lbs.						
Cornish boiler -	797·7	25·0	520	20·8	3160	6·08	6·74	3·96	1:31·9
Multitubular boiler	1355·0	25·0	520	20·8	4240	8·15	9·04	3·13	1:54·2

The experiments seem to have been carefully made, but it would have been better, as far as the comparison goes, had some other plan been adopted than burning the fuel pound for pound in the two boilers. Although their grate surface is the same, it does not follow that their most advantageous rate of combustion should also be the same; the Cornish boiler might probably have shown better results if it had been worked at 15 or 16 lbs. of coal per foot of grate per hour. The experiments are, however, valuable in themselves, and are confirmed by several others. The best results which we have seen given as having been attained by these boilers came from Brunswick. The water was admitted at 50 deg. Centigrade (122 deg. Fahr.), and evaporated at the atmospheric pressure, a 10-in. pipe being placed on the manhole so as to prevent the possibility of any water being mechanically carried away by the steam. The fuel was good ordinary coal from Barrillon pit. Under these conditions, the evaporation was 10·8 lbs. of water per pound of coal, equivalent to 11·88 lbs. from and at 212 deg. Fahr.

Next on our list comes the high pressure boiler of Herr Ehrhardt, the designer of the compound engine generally known at Vienna by the name of the "Dingler" engine, and which will be duly described in its proper section. Herr Ehrhardt's boiler, like his engine, was constructed by the Dingler'sche Maschinen Fabrik, of Zweibrücken, and it was intended to supply steam at an effective pressure of 10 atmospheres, or, say, about 150 lbs. per square inch. Like the Dingler engine this boiler presented some novel features, and as, whatever may be thought of its design, it certainly is the outcome of careful thought and study, we cannot do better than preface our description with a short statement of Herr Ehrhardt's ideas as to what a boiler ought to be, as set forth in a little brochure of his own. We should state that his remarks are intended to apply solely to boilers for stationary engines. He thinks that, as a rule, it is better to use two or more boilers rather than one large one, when the hourly consumption of coal exceeds 130 lbs., of water 90 gallons, or the total heating surface 350 square feet. It is of the utmost importance that all parts of the boiler, both outside and in, should be as accessible as possible, and this can be more easily done when the boiler is short and wide than when it is long and narrow. The two principal desiderata in a boiler are (*a*), that as much heat as possible should be developed from the coal, and (*b*), that as much as possible of the developed heat should be taken up by the boiler, and utilised in the production of steam. In order to produce these results, the grate surface should be large, and the fire thin rather than *vice versâ*, but care must be taken not to exceed a size of grate which can be easily fired by the stoker. The maximum size of grate Herr Ehrhardt fixes at 5 ft. long by 3 ft. wide; but he considers a surface of 11 square feet to be about the best for one grate. He very strongly prefers, under almost all circumstances, an inside to an outside furnace, and considers the comparatively good results sometimes obtained from the latter to be owing to the fact that an outside fired boiler is so much more easy to design than an inside fired one, and that, therefore, fewer mistakes have been made in their construction. The last flue through which the products of combustion pass before reaching the chimney should, he thinks, be over the top of the boiler, so as to dry the steam. The boiler and all the pipes, if they are exposed to the air, should be lagged. He insists very strongly that if employers of steam power wish to get anything like good results from their boilers, they must give up the habit of employing mere labourers to attend to them, and pay such wages as will command the services of a skilled stoker. We do not make any remarks by way of criticism on any of these ideas here, but merely quote them to show the principles on which Herr Ehrhardt set to work to design his boiler. We need only add, by way of explanation, that by "heating surface," Herr Ehrhardt means the whole surface of the boilers with which the flame comes into contact, and the feed-heating surface (if any) in addition; and we may mention that the engine to which this boiler supplied steam is a compound engine of peculiar construction, having cylinders 4·92 and 9·84 in. diameter respectively, and 19·68 in. stroke.

The boiler, as will be seen from the engravings, Figs. 1 to 3, Plate XXXVII., consists essentially of two horizontal cylinders, connected near each end by a

vertical pipe, and set entirely in brickwork. The lower cylinder is 980 mm. (3 ft. 2⅝ in.) diameter, and 3·495 metres (11 ft. 5½ in.) long. It contains a cylindrical furnace 700 mm. (2ft. 3½ in.) diameter by 2·195 metres (7 ft. 2½ in.) long, and having a grate with bars 1·5 metres (4 ft. 11 in.) long, and with a surface of 1·05 square meters (11·30 square feet). The space between the back of the furnace and the back of the boiler is traversed by 31 horizontal wrought-iron tubes, having a diameter of 76 mm. (3 in.) The products of combustion pass from these tubes back under and beside the boiler, pass upwards on reaching the front, and back again between the two cylinders, then again to the front over the steam space of the upper cylinder, and once more back through a separate flue—in which is placed the feed heater—on their way to the chimney. The two cylinders are connected together (their centres being 1·100 metres, or 3 ft. 7¼ in. apart) by two vertical tubes, about 18½ in. diameter, and the upper cylinder is a little longer than the lower, but only 865 mm. (2 ft. 10 in.) diameter. The feed heater consists of six tubes, 89 mm. (3½ in.) diameter, and about 3·5 metres (11 ft. 5½ in.) long, having a total heating surface of 5·8 square metres (62·42 square feet). These tubes are so connected that the water has to pass through the whole of them before entering the boiler. The steam for the engine is taken through the upper side of a perforated pipe, which extends along the greater part of the length of the upper cylinder. The feed water is introduced near the bottom of the front of the upper cylinder. The feed pipes and valves are so arranged that, if necessary, the water can be sent directly from the pump into the boiler, and the feed heater taken entirely away for repairs or cleaning. A wrought-iron cylindrical sediment box, 19½ in. diameter by 14 in. deep, is rivetted to the bottom of the boiler, and through it the boiler is blown off. There is also a surface blow-off cock fitted on the same mounting as the feed inlet pipe (to avoid cutting another hole in the boiler), and having a pipe communicating with a settling box in the upper boiler. Doors through which access can be had to the flues are provided behind both boilers.

The wrought-iron flue leading to the chimney is rectangular in section, 500 mm. high by 510 mm. wide (19·68 in. by 20·07 in.), and is fitted with the usual damper. The room occupied by the brick setting is 2·2 metres (7 ft. 2⅜ in.), wide by 3·17 metres (10 ft. 4¾ in.) high by 4·15 metres (13 ft. 7½ in.) long. These boilers are made only in two sizes, the one illustrated, and a smaller one with two-thirds as much heating surface. Herr Ehrhardt, as we have said, considers it more advantageous to use several smaller boilers than one larger one. The following are the principal particulars about the boiler illustrated:

Grate surface - - - -	11·3 sq. ft.
Total heating surface of boilers - -	269·07 ft.
Surface of feed heater - - -	62·42 „
Total heating surface - - -	331·49 „
Coal to be burnt per hour, at rate of combustion considered most advantageous, about - - - - -	100 lbs.
Steam produced per hour with this amount of fuel, about - - - -	660 „
Steam pressure per square inch above atmosphere - - - -	150 „

We do not see why such a very small combustion of fuel per foot of grate should be insisted on; but even supposing it were advantageous to burn only 9 lbs. of coal per foot per hour, there is certainly no reason for setting down the evaporation as only 6·6 lbs. of water per pound of coal, especially as the boiler has ample heating surface. To insure the economical production of steam it is almost as necessary to use good fuel as to employ a good stoker, and with both of these, and the use of Ehrhardt's boiler, an evaporation of at any rate 10 lbs. of water from and at 212° Fahrenheit, should be obtained. The figures we have given are, however, those supplied by the inventor.

Besides the boilers already spoken of, there was also shown at work in the German boiler house one by the Schlosschemnitzer Dampfkesselfabrik

Actien-gesellschaft, of Chemnitz, this boiler being in many respects similar to those of Messrs. Paucksch and Freund, alongside which it was placed. In the engravings on Plate XXXVII., Fig. 4 shows a side elevation of the boiler, with a section through the setting; Fig. 5 a cross section of the boiler, furnace, and brickwork; and Fig. 6 a front elevation, showing the fire-doors, &c. The boiler is constructed to work at a pressure of 75 lbs. per square inch; it is 4·35 metres (14 ft. 3¼ in.) long and 1·595 metres (5 ft. 2¾ in.) in diameter. It contains 50 tubes passing through its whole length, each 76 mm. (3 in.) diameter, and these tubes, as in the boiler above alluded to, are arranged in two nests, with a clear space of 12 in. between them, so that a man can easily move along the whole length of the boiler inside. Ample space is also left below the tubes, for a man kneeling, to clean the scale from the bottom of the boiler shell, the place, where owing to its being immediately over the fire-grate and thus exposed to the most intense heat, the most deposit will always be formed. Two oval tubes are attached to the front end of the boiler, and pass through the brickwork. Of these the upper one serves to carry the water gauge and gauge cocks, and the lower one is fitted with a manhole door. A separate cylindrical steam chamber, 3 metres (9 ft. 10⅛ in.) long by 650 mm. (2 ft. 1⅝ in.) diameter, lies horizontally over the boiler, to which it is connected by two vertical pipes, and upon this the safety valve, stop valve, &c., are placed. While it is certainly advisable not to brick this chamber up out of sight, it would nevertheless be a great economy to clothe it (as could easily be done) with some non-conducting composition, which would at the same time prevent radiation and yet show at once by its colour if there were any leak, or if any water were lying underneath. There are three manholes altogether provided, one in the tube above mentioned, one in the end of the steam chamber, and one (not seen in the Figures) on the boiler shell itself. The latter might easily be dispensed with, as communication between the steam chamber and the boiler itself is so easy; but too ready access to the interior of a boiler is not a thing that any one would be disposed to grumble at. The furnace, it will be seen, is external, and fed through double firedoors The grate is 4 ft. 8 in. wide, and 5 ft. long, having therefore a surface of 23·33 square feet. The products of combustion, after passing under the boiler, and returning through the tubes, pass back again by side flues, and so into the main flue, which lies underneath the back of the boiler, and is provided with the usual damper. Smokebox doors are provided in front for cleaning the tubes, and also additional doors directly opposite the ends of the side flues, by which soot and deposit of other kinds can be easily raked out of them, and scraped off the side of the boiler without the inconvenience of keeping the large smokebox doors open.

The boiler has a total heating surface of 64 square metres, or 688·8 square feet, which bears a ratio to the grate surface of nearly 30 to 1. We have no particulars of experiments on the evaporative power of this boiler, but see no reason why it should not stand well in this respect; and it is certainly very gratifying to see the care which its makers, along with some other German firms have taken to make a boiler which should be durable, and work well under ordinary conditions, rather than a boiler with very high evaporative qualities combined with objectionable complexity of construction, or great inaccessibility of its different parts.

The last German boilers we have to notice were two exhibited by Herr Julias Bergmann, of Hattingen, in Westphalia. These were not shown at work but were placed outside the German boiler house, in a position where every part of them could be freely inspected. Their construction is somewhat novel, and the boilers themselves have excited a good deal of attention in Germany.

In the engravings Plate XXXVIII., Fig. 1 shows a front and a side elevation of the boiler, with corresponding cross sections of its furnace and brick setting. Fig. 2 is a vertical section of the boiler only. Fig. 3 shows a cross section of the boiler and furnace along the line B, B′′′′ in Fig. 1, while Fig. 4 is a similar section along the line A, A′′′. Figs. 5 and 6 are sections through the upper and lower horizontal branches respectively. The boiler consists essentially of two cylinders, of which the upper one is larger in diameter and

shorter than the lower one. The lower cylinder is 10 ft. 3¾ in. long by 2 ft. 7 in. diameter; its bottom end is entirely embedded in brickwork for a depth of about 14 in. A wrought-iron sediment tube, which also is mostly embedded in brickwork, and which is 1 ft. 9½ in. in diameter, is rivetted to the shell as near the bottom as possible. In the cover of this tube are the feed valve and the blow-off valve, but the latter is thus necessarily several inches above the lowest part of the boiler. The upper part of the boiler is 4 ft. 7½ in. in diameter by 5 ft. 6 in. high. From its lower plate hang suspended 44 tubes of the kind well known in England as Field tubes, that is, water tubes closed at the lower end, and having an internal circulating tube with a bell-mouth at top. These tubes, as will be seen from the engravings, are placed so as to hang vertically in a double ring round the lower part of the boiler. They are 3 in. external diameter, and 4 ft. 8 in. long. On the upper end of each a conical ring is welded, and the holes in the tube plate (which seems to us extremely thin) are bored of the same taper as the ring, the tubes being kept tight by the pressure of the steam. In order that the steam and water gauges may be placed directly on the boiler, and not connected to it only by tubes through the setting, a cylindrical box is rivetted on the upper shell of sufficient length to extend through the brickwork, and on the front of this are attached, as will be seen, the gauges. On the top of the boiler is a small steam dome, on which stand the stop and safety valves, the latter being inclosed in a lock-up case.

The furnace, it will be seen, is entirely external to the boiler itself, and is constructed of brickwork lined with firebricks. The grate is 4 ft. 11 in. long (the firebars being in two lengths) by 4 ft. 3 in. wide. The surface is all in one; but there are two fire-doors, so as more easily to distribute the fuel. The flues are arranged so as to compel the products of combustion to pass spirally round the lower shell and among the tubes in the way indicated by the arrows. After leaving the tubes they go direct to the chimney, scarcely playing at all on the upper part of the shell, which is almost entirely embedded in brickwork.

To all intents and purposes this boiler may be described as a Field boiler with external firing, the points in which it differs from the ordinary Field boiler being almost all owing to the fact of its being externally fired. Numberless advantages are, however, claimed for it over the Field; indeed, in one enthusiastic scientific Austrian journal we saw it described as "marking an epoch in the history of boiler construction." After a careful examination of it, however, we are not able to join in any such expression of admiration. The strong points about the boiler seem to be that almost all deposit will be separated from the water during its ebullition in the larger central water tube, and therefore the danger of the tubes burning from internal scale will be to a great extent obviated; and that the way in which the flame is conducted through among the tubes may possibly increase the efficiency of their surface over that in the ordinary arrangement. Here, however, we think the special advantages end. The boiler will be, for an equal surface, somewhat lighter than a Field boiler (although not, as asserted, in the proportion of 10 to 17); but against this may fairly be set the fact of its requiring a heavy and expensive brick setting, which the other does not want at all. We cannot here discuss the question of internal or external firing. Continental engineers are much more fond of the latter than we are, but it is of course true that in a vertical boiler it is difficult to get sufficient proportional grate surface in an internal furnace, especially when (as is so commonly the case) very inferior fuel has to be burnt. But the great drawback of this boiler is certainly the extreme inaccessibility of its parts. If the maxim already quoted, that in a boiler "durability is a function of accessibility" be true, this boiler cannot be destined to last very long. It will be seen that much of it is absolutely built up in brick, and in the seams thus covered up and out of sight corrosion by water or otherwise may be leisurely going on while the engineer remains in complete ignorance of the fact. We are told that any tube can be knocked out easily by one blow of a hammer from below, but only with considerable difficulty can any of the tubes be got at, and only a very few of them are in such a position that they could be struck from below with a hammer. Two holes in the brick setting are certainly provided, by one of which a boy might

crawl into the flues, and by the other a man might look at the tubes, but even these must—while the boiler is at work—be closed by firebricks, and these bricks taken out and put back again every time the holes are used. It is not only necessary, however, to the proper cleaning, and even to the safety of a boiler that access should be had to every part of it (which is not the case in the boiler before us), but that *easy* access should be had, without pulling down brickwork or squeezing oneself into tortuous passages. If nothing better than this is provided, the result will be, as owners of boilers know too well, simply that the boiler will remain uncleaned. This is a matter of so much practical importance to the efficiency, as well as the safety of the boiler, that when it cannot be attained without sacrificing some of the efficiency (on paper) of the boiler, this sacrifice should unhesitatingly be made. In justice to the inventor we mention here what is considered one of the chief points about the boiler, viz.. "that, above all, in all parts of the boiler exposed to the action of the flame, lengthened forms are used, offering a large surface in proportion to their contents, but in the parts exposed to the cooling influence of the atmosphere shapes are used more nearly approaching the spherical, and possessing large contents in proportion to their surface." This is beyond question quite correct both in theory and for practice, and our readers can judge for themselves how far it is more carried out in Bergmann's boiler than in others.

An experiment made with this boiler showed an evaporation of $7\frac{3}{4}$ lbs. of water per pound of coal (small), but the experiment was not sufficiently complete to make it worth while publishing the details in this place. We have no doubt that with good coal the boiler would show very fair evaporative results.

Austria.

We now come to Austria, whose boilers were exhibited in four different sheds. We will first take the one which supplied the steam to the Machinery Hall. It contained a set of three boilers by Sigl, the well-known locomotive and machinery maker of Vienna, Berlin, and Wiener Neustadt, the leading principle governing their construction being, as will be seen from the engravings Figs. 7 to 9, Plate XXXVIII., that the gases and the water shall move throughout in opposite directions, and so fulfil one of the conditions which theory has shown to be advisable, but which is not well complied with in the ordinary types of boilers. The three boilers are identical in their construction, each consisting of a main shell or boiler proper, 4 ft. 6 in. in diameter by 34 ft. 6 in. long, and two water tubes, or "bouilleurs," placed underneath it, and 2 ft. 6 in. in diameter, by about 32 ft. long. The main boiler is inclined downwards from front to back 9 in. in its length. At the back end it communicates, by means of an 18-in. tube, with the higher end of one of the "bouilleurs," which also has a fall of 9 in., but towards the front instead of the back. The front ends of the two water tubes are on the same level, and communicate freely by means of an 18-in. pipe, while the second tube is arranged with a fall of 9 in. towards its back end, at the lowest point of which the feed water is introduced.

The gases of combustion pass under the main boiler, then downwards, and towards the front along the first "bouilleur" and finally along the second "bouilleur," to the chimney. The arrangement of the flues will be seen from Fig. 9, Plate XXXVIII., in which the setting of the left-hand boiler is shown in section at the back end, that of the middle boiler at the front end of the lower flues, and that of the right-hand boiler across the back of the ashpit. From the description we have given of the construction of the boiler, it will be at once seen that the feed water and escaping gases must move in exactly opposite directions, so that just as the water becomes heated it comes in contact with gases of still higher temperature. It is of course essential to the success of a boiler arranged like these of Herr Sigl's that steam should only be generated in the main boiler, and not in the water tubes.

These boilers are fitted with Zeh's patent firegrate, which, by way, was the only mechanically fired grate at the Vienna Exhibition. The bars are set at a very steep angle, and the fuel is placed by the stoker in a fixed hopper outside. By means of eccentrics revolving slowly, the coal in the hopper is gradually

and uniformly jerked on to the grate, the steepness of which insures its continually finding its way downwards. It is claimed for this grate that it causes very perfect combustion of the fuel, and so makes the steam-producing qualities of inferior coal burnt upon it as great as those of good coal burnt on ordinary grates, and also that any kind of dross or small coal can be burnt upon it. The eccentrics are driven by the steam donkey pumps which feed the boiler. Zeh's grate is used by a number of large firms in Vienna, who speak well of its capacity for economically using some of the inferior Austrian brown coals, &c., but on this subject we cannot say anything definite, not having before us the particulars of the experiments which are said to have been carried out with it.

Each of the three boilers we have been describing has 700 square feet of heating surface, and 21·5 ft. of grate surface. The working steam pressure is 75 lbs. per square inch above the atmosphere.

A fourth boiler exhibited by the Prager Maschinenbau Gesellschaft was shown outside the shed containing Sigl's boilers. It was made on Kux's patent, and consisted of a long horizontal cylinder with internal firing, with one "bouilleur" under it. At the back of these two were a pair of vertical cylinders, or drums, of the same diameter as the main boiler, standing one above the other, and connected together by a number of water tubes. The hot products of combustion, after passing through the flue of the main boiler, circulate among these tubes, and are then conveyed by an external flue round. the "bouilleur," at the front end of which latter the cold water is introduced. The main boiler is, of course, in direct communication with the upper vertical drum, while the "bouilleur" communicates in front with the main boiler, and behind with the lower drum. The object of all this arrangement is to insure a circulation by the ascent of the water in the tubes when these latter are heated by the hot gases.

The second Austrian boiler house contained the steam generators for working the pumps at the extreme eastern end of the Machinery Hall. In this shed were a boiler by the Grazer Maschinenbau und Stahlwerks Gesellschaft, and a multitubular boiler of the locomotive type by Baechlé, of Vienna. The only noticeable point in the latter is that the fire-box crown is stiffened by being dished down instead of being stayed in the ordinary way. The boiler by the Gratz firm in some respects resembles that introduced by Sir William Fairbairn, and consists, as shown by Figs. 5 and 6, Plate XXXIX., of a top barrel placed horizontally, and having a diameter of 3 ft. and a length of 22 ft., the barrel being made of iron plates one-third of an inch thick. This top boiler is connected by vertical tubes with the bottom barrel, which has a diameter of 45 in. and a length of 21½ ft., the thickness of the iron plates being five-twelfths of an inch; the bottom boiler, which contains an internal flue 30 in. in diameter, is not placed quite horizontally, but at a slight incline downwards towards the front. The flue contains the fire-grate, as shown, and the products of combustion pass through the flue, then along the outside of the bottom boiler, and passing next through a flue into the upper part of the setting escape into the chimney after having traversed the under surface of the top boiler.

The flue is not rivetted into the bottom barrel, but is bolted to it by strong flanges made of 3 in. square iron, copper washers being used for the joints. The flue can thus be taken out when desired. The flue is quite smooth on the inside, but is strengthened by stiffening rings of the section shown. The feeding of the boiler, as well as the blowing off, takes place at the lowest point of the bottom barrel, and the steam is taken off from the dome of the top boiler, where are also fixed the two safety valves, each of a diameter of 3 in. The top barrel is provided with a circular man-hole casing which projects above the setting, so that the boiler can easily be opened. The total heating surface of this boiler is 445 square feet, and the working pressure is 6 atmospheres, or say 90 lb. per square inch.

We can now return to the western end of the Machinery Hall, where in a detached building there were a pair of boilers, on Dessin's system, by the Erste Brunner Maschinen Fabriks Gesellschaft. Each of these is a horizontally-lying cylinder, debouching at the rear end into a large vertical drum full of fire tubes. (See Plate LXVII.) The furnace is external, and the

hot gases, after travelling along the bottom of the horizontal cylinder, pass through the tubes in the drum. These tubes are arranged in four separate clusters, with a cross-shaped passage left between them, in order to admit a man for cleaning purposes. We shall have more to say of these boilers when describing the engines to which they belong.

The next and last boiler house was that attached to the pumping station situated just behind the Jury Pavillion. There were two boilers to be seen here, exhibited by the firm of Bolzano, Tedesco, and Co., of Prague, and employed in generating steam for the pumps by Messrs. Decker Brothers, of Canstatt, which supplied the fountains with water, and which we shall describe in their proper section. The construction of the boilers is made very plain in the engravings, Plate XXXIX., Figs. 7 to 11. Each boiler consists of two parts, the lower being an ordinary multitubular boiler, and the upper a cylindrical steam chamber or superheater. The feed water is introduced into a long oval tube rivetted to the back of the shell, which also provides access for cleaning to the space below the tubes. The upper part of the main boiler can be entered through the superheater, on which are placed the safety valves and stop valve. In the boilers shown at Vienna each main barrel was 5 ft. 8½ in. in diameter by 10 ft. 4$\frac{5}{16}$ in. long, and it contained 83 tubes 3 in. in diameter outside. Each steam chamber or superheater was 2 ft. 10¼ in. in diameter, and 15 ft. 1⅛ in. long.

The boilers require a great deal of brickwork in the setting, which must be proportionately expensive. As far as evaporation goes, they should give good results (although the addition of a feed heater would be an advantage); but we do not at all like the way in which the upper half of the shell of the main boiler is arranged—it will be impossible to get at it without pulling down brickwork, which is almost equivalent to saying that no one will ever take the trouble to look at it at all.

These boilers were fitted with Bolzano's patent fire-grate, this grate being the invention of M. Theodor Bolzano, the principal manager of a spinning mill at Schlau, in Bohemia. M. Bolzano was led to design this grate from having to deal with a class of coals containing 40 per cent. of ashes and refuse, a fuel which cannot be economically consumed on ordinary grates.

From the engraving Plate XXXIX., Fig. 11, it will be seen that M. Bolzano's arrangement consists, in the first place, of a plate *a*, situated about 10 in. above the upper set of bars, this plate being mounted on trunnions so that it can be turned, and the coal placed on it thus deposited on the surface of the upper grate *b*, where it can be distributed by a rake. The bars of the upper grate *b*, and also those of the lower grate *c*, are inclined at an angle of 12°, and every alternate bar in each grate is movable. The movable bars are capable of being raised by the levers *d d*, as shown, and in this way the grates are readily cleared if the fire appears dead. Any clinkers or cinders which fall through when the bars are moved, are collected and replaced on the fire. The bars, it will be noticed, are stepped at their lower ends.

At *f*, is a plain grate, situated about 3 ft. 5 in. below the boiler, this grate being mounted on slides, so that it can be drawn out when necessary. At *g* is the bridge as usual.

In using this arrangement, it is necessary that the fireman should take care that the spaces below the bars at *b*, *c*, *e*, and *f* are always well covered with coals, so as to avoid the admission of cold air. The vertical spaces between the grates are generally made about 2½ in., they being thus large enough to allow of the introduction of a rake or slice, to break up the caked coal when necessary. In working, the fire is first stirred on the upper grate *b*, and then passed on to the lower grate *c*, where it is again broken up when necessary, and finally, the unburnt cinders and clinkers are pushed forward on to the grate *f*, and after they have remained there some time the grate is withdrawn and the refuse allowed to fall into the ash-pit, the grate being immediately pushed forward again and re-charged with fuel from the lower part of the grate *c*. The grate *c*, is also made to receive a supply from the grate *b*, and the latter is charged with fresh coal by turning the plate *a*.

The fireman has thus a consecutive series of operations to perform, but the labour involved is not great. The combustion is stated to be very perfect, a

clear white flame of high temperature being obtained even with the very inferior coal available in Bohemia, while the finest coal dust can be effectually burned. The arrangement also has the advantage not possessed by ordinary step grates, of allowing the fire to be forced when necessary.

In the boilers at Vienna each grate measured 6 ft. $6\frac{3}{4}$ in. by 4 ft. $2\frac{1}{4}$ in., its area being thus $27\frac{1}{2}$ square feet. This fire-grate was designed specially to enable the inferior Bohemian coal to be economically burnt; but there is no reason why it should not be used with better fuel, with which we think it is calculated to give good results. Experiments made with this grate at the shops of the Buschtiehrader Railway at Kommatau, Bohemia, have shown that with the use of washed small brown coal (1 lb. of which evaporates about $2\frac{1}{2}$ lbs. of water) an economy is effected of 46·5 per cent. compared with the fuel consumed on an ordinary grate with steps. It was proved however at the Exhibition that the grate was also very suitable for bituminous and poor coal, and that it produced a satisfactory combustion of the smoke; the latter circumstance was of great importance at Vienna, on account of these boilers having been situated in the most frequented part of the Prater and the Exhibition grounds, where the presence of smoke would have been attended with inconvenience. This was the only grate at Vienna which was recognised by the jury, whilst the Mitarbeiter-Medaille (medal for co-operators) was awarded to the inventor.

We have in the present section confined our remarks to fixed boilers only, but there were also exhibited at Vienna several examples of semi-portable boilers well worthy of notice, and these we intend to describe in due course in the section dealing with the engines to which they belonged.

Economisers, Feed-water Heaters, and Boiler Feeders.

In speaking of the English boiler houses we have already alluded to the three economisers Green's, Twibill's and Bell's there exhibited and we now propose to describe their arrangements in greater detail. In the general principles of their construction Green's and Twibill's economisers are similar Both consist of a number of vertical cast-iron pipes standing in rows upon horizontal cross pipes, which in turn are attached at one end to one horizontal supply pipe. At the upper ends the vertical pipes are connected also to horizontal cross pipes, which again are coupled to one longitudinal pipe leading off to the boilers. The other ends of these lower and upper cross pipes have blank flanges, or are cast closed. The whole apparatus is placed in an enlarged portion of a flue close behind a boiler or range of boilers, and the heat of the gases passing from the boilers to the chimney permeates through the spaces intervening between the vertical pipes. The boiler feed is forced into the end of the lower supply pipe furthest from the boiler, and passes out at the boiler pressure from the upper or delivery pipe at the end which is nearest to the boiler. The upper part of this nest of pipes will of course be the hottest.

The water having once arrived at the foot of any one vertical pipe will gradually have to pass upwards, and away by the top connexions to the boiler. Thus the cold water is always entering the coldest portion of the pipes, and having become heated during its ascent, passes away from the hottest part, and does not again descend to the cooler portion below. This is an important element in the well-being of the joints of "economiser" pipes, as all irregularities arising from intermittent expansion and contraction and risks appertaining thereto, are avoided. The speed with which all the heated particles of water will rise in any one pipe is a matter determined by natural causes, each pipe being free in itself from the effect produced in any neighbour, while sandy deposit has time to settle quietly down into the bottom cross pipe in cooler water.

Incrustation, however, will still take place notwithstanding, but this is found to occur mainly at the upper part of these vertical tubes. A considerable height or length of vertical pipe is therefore desirable in order that as great a proportion of good and uncoated pipe as possible may be in a regular course of working exposed to the action of the hot air of the flue. Both Green's and Twibill's economisers are dependent on being kept free from the

deposit of soot upon the surfaces of the vertical pipes, and scrapers are therefore employed to keep them constantly cleaned. Having thus pointed out the general similarity, we next notice the little details in which differences appear, referring for that purpose to Plate XL., on which Twibill's economiser is represented. The economiser shown on this Plate we may add is not that exhibited at Vienna by this maker, but an example of apparatus constructed by Mr. Twibill in his regular practice, the economiser represented being one erected at Messrs. Cephas Howard & Co's., Portwood Mills, Stockport, where it is worked in connexion with boilers supplying steam to engines indicating 1,800 horse power.

In Twibill's economiser, as in Green's, the bottom ends of the vertical pipes are slightly conical, turned to gauge, and tightly pressed into sockets on the bottom cross pipe, which are bored out to receive them. The upper ends of Twibill's pipes have a flat flange, by which, with four bolts to each, they are attached to corresponding flanges on the branches cast on the top cross pipe. These faces are also turned, and the joints made metal to metal. The top and bottom cross pipes are in like manner attached to their supply and delivery pipes by bolts and nuts. The roof or top is formed by closing plates of cast iron laid loosely upon these cross pipes. In the event of any one pipe having to be removed, one top cross pipe has to be detached from the delivery pipe, and from all the other pipes of the same set; the defective pipe can then be withdrawn, and another be put in, and all be bolted together again. One advantage in this arrangement is that all the connecting pipes are cylindrical. In Green's economiser, the top arrangement is different, all the top cross pipes being made with bored sockets to receive the upper ends of the vertical pipes, which are pressed into them by hydraulic pressure the same as at the bottom. The top cross pipes are made so as to lie side by side in close contact, and being furnished with projecting lugs at the ends are thereby bolted together, and form the top or roof complete. But access to each individual pipe, and the means for the removal of any one single pipe or any number of them, is provided without any other disturbance of the whole apparatus beyond the removal of the one circular cover immediately above each pipe. The entire top surface of this economiser is open to view, and if the boiler connexion be shut off any one of these small covers can be instantly taken off. If the pipe needs to be removed it can be drawn out by suitable hooked bolts and a new one be put in, in a very short time, without the disturbance of any other joint. Another advantage afforded by these lids is that not only can the internal condition of the pipes be easily and periodically ascertained by actual examination, but in case of incrustation taking place to a serious extent, the tube can be bored out from the top without removal. Al the joints formed by bolts and nuts and flanges are in this arrangement kept outside of the flue and free from the brickwork, so that all parts are accessible. Covers are provided at the ends of the horizontal connecting pipes both at the top and bottom, upon the removal of which any such pipe may be examined and cleaned out. A great deal of care has been bestowed by both makers upon the form of the soot scrapers. They are now both made double-ended, so that the full length of every pipe may be scraped, and they are also so made that any one can be without difficulty removed and replaced when required. Twibill's scraper (see Figs 4 and 5, Plate XL.) consists of two parts, each embracing half the pipe, and having as it were knife edges upwards and downwards to suit the two corresponding motions that are given to them when at work. They rest upon inclined surfaces formed in the carrying bar, so that they may at all times be kept in close contact with the pipe. By the arrangement of a long part at the top and a short one below the point at which they are supported, a certain leverage is brought to bear to insure a proper scraping action on the downward movement. In Green's arrangement the scrapers are in three sections instead of two, and it is evident that a pipe can be better embraced by three sections together forming a circle, than by two, and the longer they are in use the more will this be evidenced as wear takes place,

Upon the efficiency of these scrapers depends, to a very large extent, the value of the economiser, and great stress is consequently laid by the makers

on the value of the forms they each adopt. It is essential that a strictly true scraping action and not a mere rubbing shall take place, because the sooty deposit is easily rubbed into a kind of black plaster, the coating of which upon the pipes of an economiser would seriously detract from its usefulness. The internal taper shown in Twibill's scraper does not exist in Green's, in which the corners are rectangular. Mechanical action from some convenient source is brought to bear upon the chains supporting the transverse bars which carry the scrapers, and by a suitable arrangement of frictional attachments to the pulleys over which the chains hang, the scrapers become self-adjusting.

The spiral tube economiser of Mr. Andrew Bell, of Haslingden, is shown by Figs 6, 7, and 8, Plate XL. From these views it will be seen that the economiser consists of one, two, or more coils of cast-iron piping of 4-in. bore, three such coils being shown in our engraving. There are nine twists in each coil, and the latter are built up of semicircular lengths of pipe, the length being reduced in diameter at the ends, and connected by turned and bored socket and spigot water-tight joints, these joints being each overlapped by a hoop of cast-iron run round the pipe as shown in the detail view, Fig. 8, Plate XL. The hoops thus cast on gather round external ribs cast on the pipes, and as they cool they contract and draw the turned joints very firmly together. The extent to which the lengths of pipe are reduced in diameter at the ends is equal to the thickness of the hoops placed over these reduced portions, so that a constant external diameter is maintained throughout. The coils have thus the appearance of being formed in one piece, and their exteriors are left smooth for the action of the scrapers. A number of coils thus formed are connected to constitute an economiser, the first being joined to the second at the top, the second to the third at the bottom, and so on. Or the connexion may be from the top of No. 1 coil to the bottom of No. 2, and thence on in the same way through all, the number of coils depending upon the circumstances of the case. The water enters at the end furthest from the furnace, and passes on towards the hottest part, gradually absorbing heat from the escaping gases. It is stated that the circulation of water through the coil is such as to prevent the incrustation of the pipes in a great measure, and that even should incrustation take place, any piece of the coil can be easily removed by breaking off the muff coupling, and the cleaned pipe, or a new pipe, be replaced in a short time in the same way as at first it was fixed, namely, by running molten metal round about the grooved ends.

The scrapers for removal of sooty deposit are shown by Fig. 7, Plate XL., and are formed on what is termed the "finger and thumb" principle; the thumb or bottom scraper being loosely suspended from the finger or upper part of the arm, and made to clip the pipe tightly by means of a balance weight at the end of a lever within the diameter of the coil. These scrapers are carried by a diametrically placed bar, which is caused to revolve by tie rods attached to cross arms carried by a wrought-iron vertical shaft in the centre of the coil. The scraper is also mounted on this shaft, but is free to slide upon it vertically, and the coils acting the part of a leading screw the scrapers are carried up and down as the shaft revolves, first in one direction and then in the other. The shafts carry worm wheels at their upper ends, these being driven by worms situated on a shaft driven as shown, the direction of motion being reversed at suitable intervals. The reports we have seen on the performance of these scrapers speak very favourably as to their efficiency. An advantage claimed for these coil economisers by Mr. Bell is the facility with which they are erected, the entire machine being self-contained in an iron framework stand on the bottom of the flue. Another advantage consists in the efficient way in which the pipe surface is exposed to the escaping gases, the pipes on one side of each coil being partially opposed to the spaces on the opposite side, while experience has shown that the introduction of the apparatus effects no material injury on the draught, a very important point to be taken into consideration in estimating the value of an economiser.

Analogous to the "economisers" are the feed-water heaters now so extensively used, and of which several varieties were represented at Vienna. Some of these, being attached to engines, will be described in the section of

this report dealing with those exhibits, while of two others, Waters's and Berryman's, we have to speak here. Both these heaters were exhibited by Messrs. Whitley Partners, of Leeds, and they may be taken as examples of the two chief types of such heaters in use, the first belonging to the class of "open heaters" in which the feed-water comes into direct contact with the exhaust steam, while the latter is a "closed heater," the exhaust steam on its way through the heater imparting a portion of its heat to the feed-water but not mixing with the latter. In many cases the admixture of the exhaust steam with the feed-water has given rise to much trouble the grease carried over with the former combining with some of the impurities in the feed water and forming a coating on the surfaces of the boilers, which has resulted in serious cases of overheating. For this reason the various boiler inspection companies have nearly all reported strongly against the use of "open heaters" and although the latter are no doubt harmless in many cases, they should only be used with judgment. The closed heaters on the other hand possess other advantages besides that of keeping the feed water clear of any grease carried over by the exhaust. Thus when town water is supplied at sufficient pressure it can be run through them direct into the boilers, while they can also be pumped through, the feed pumps thus drawing cold instead of hot water as is necessarily the case when open heaters are used.

Of Waters's feed-water heater just referred to engravings are given on Plate XLI., Figs. 2 and 3. This heater has been designed by Mr. Horatio N. Waters, of Hartford, Connecticut, U. S. Referring to the section Fig. 2, it will be seen that the heater consists of a reservoir or casing A, into which the cold water flows from a cistern through the pipe B, and perforated pipe or "sprinkler" C, this latter distributing it in the form of a number of fine jets. The flow of water is regulated by the cock H, so that it is maintained at a proper level in the casing, as shown by the glass gauge G.

The exhaust steam from the engine enters through the pipe D, and impinges against the deflector E, which deflects it downwards again against the sprinkler C. That portion of the steam which is not condensed passes round the edges of the deflector E to the exit pipe F at the top of the apparatus. The feed pipe I leading to the pump, is turned down inside the reservoir, as shown, and terminates about 4 in. above the bottom of the casing, so that the pumps can draw without disturbing the sediment. At the bend of the pipe I there is attached an air pipe J, which extends upwards above the highest water level M in the reservoir. This pipe is for the purpose of admitting air or steam to the pumps through the pipe I when the water level falls below the line N so that the pumps cannot draw off the water below that level. When the pump is situated below the pipe I the water will flow out to the level N of the bottom of the inside of the pipe, but when the pump is above I the lowest water level producible will be on a line with the top of the inside of the pipe I. At L is a handhole for giving access to the interior of the heater for cleaning or other purposes, while K is a plug for drawing off the water from the casing when desired, and P is an overflow pipe or plug to prevent the water from rising sufficiently high to enter the pipe D. In addition to acting as a water heater merely, the arrangement we have described serves to collect the major portion of the solid matters contained in the feed-water. By the employment of the sprinkler the water is brought into such intimate contact with the exhaust steam that it is raised quite to the boiling point, and the arrangement of the reservoir and feed pipe allows the solid matters which become separated at that temperature to be deposited before the water is pumped into the boiler. In certain cases, however, the saponaceous deposits to which we have alluded above, may be formed in the boiler itself.

The other heater above referred to as being exhibited by Messrs. Whitley Partners, is that designed by Mr. Robert Berryman, of Hartford, Connecticut, and it is also shown on Plate XLI., Figs. 4, 5, and 6. The views there given represent a pair of these heaters working in conjunction, an arrangement which is adopted under certain circumstances for reasons we shall explain presently. The water inlet is at B B, this inlet being at such a height that any deposit formed on the tube plate is not disturbed by the entering water. The tube

plate of each heater also is made concave, and from the lowest or central point a blow off pipe H is led away. The hot water is drawn off at the tops of the heaters at C C. The exhaust steam from an engine is more than sufficient to heat the water required for the boiler supplying that engine with steam, and thus it is sometimes convenient to use two heaters arranged as shown, one heater having sufficient exhaust steam led through it to give to the feed water the maximum temperature attainable, while the other heater receives the exhaust steam not condensed in the first, and is used for heating water for other purposes than boiler feeding. The lower chamber of each heater is divided into two parts, these two parts being placed in communication with each other by the bines of bent solid drawn brass tubes F F F. Thus in the arrangement shown the exhaust steam enters at G, passes from the first division of the chamber P to the second division through the series of tubes, enters the second heater at L L, traverses the tubes of that heater, and finally escapes at E. Drain pipes to each compartment of the lower chambers are provided at I I. The mode of fixing the tubes is an excellent one and is shown by Fig. 3. To give increased length of bearing, the tube sheet has bosses cast upon it, while the tube holes are not bored right through, a shoulder being left against which the tube rests as shown. The tubes are fixed by expanding them in the tube sheet. The heater is altogether a very good one and we have heard excellent accounts of its performances.

Messrs. Whitley Partners were also the exhibitors of some feed water regulations of Mr. Berryman's, of one of which an engraving is given on Plate XLI., Fig. 7. This apparatus consists of a cast-iron sphere, with two pipes leading from it into the boiler, the one from the top, the other from the bottom. The former pipe descends within the boiler, to the line of lowest water level, the other is carried to a greater depth. The sphere is suspended by knife edges *h* upon the end of a lever, which, as shown in the engraving, is pivoted on a bracket at the side of the boiler. Attached to the lever is a link *e*, as shown, taking hold of the lever *h*, which actuates the water valve regulating the supply to the boiler. When it is put in operation the tap *d* is turned, to permit the exit of air, and the pressure in the boiler fills the sphere with water. Thus weighted, the lever *h* is maintained in one position, and the water supply is shut off from the boiler. But if the water falls beneath the lowest level, the steam enters the pipe *c* and replaces the water which passes back into the boiler through the pipe leading from the bottom of the sphere. The diminished weight of the sphere upsets the equilibrium of the levers L and *h*, the water valve is opened, and the normal level restored. In another modification, a whistle can be sounded by the disturbance of the sphere, and the alarm thus given is continued until the water in the boiler has risen sufficiently to cover the end of the pipe.

Other forms of Mr. Berryman's feed regulators are also shown by Figs. 8, 9, and 10, Plate XLI. In these views Fig. 8 shows a combined regulator and alarm of simple construction. Referring to the figure it will be seen that the bottom of the cylinder A is set 6 in. below the feed or true water level, and the pipes B and C connect the interior of the machine with the interior of the boiler, B connecting the top of the cylinder to the feed line, while C is connected at any convenient point below the water line, and conducts the water back to the boiler at each change. In the casing A is a bucket which is suspended from one end of a lever; the other end has a square cast in it, which fits a coresponding square on the rock shaft, one end of which extends through a stuffing box. To this end the lever D is fastened by a dowel pin and a clamp. The lever D, through its connecting rod, controls a valve in the steam pipe of a steam pump, or, as represented, the inlet valve of a plunger pump; it can also be used in all cases where the water pressure used to feed the boiler is greater than the requisite steam pressure.

Its operation is such that, when the boiler is supplied with water so as to cover the inlet of the pipe B, on the feed water line (steam having been raised, and the air blown out through the cock on the top of the casing A,) the casing will be at once filled with water. The bucket inside being thus immersed, the weight of water displaced by it will act on the counterbalance on the lever D, moving it down, thereby fully or partially closing the supply

valve, which valve is adjusted by the right and left screws on the connecting rod.

When the water in the boiler has evaporated to a level below the inlet of the pipe B, on the feed line, steam enters, filling the upper part of the casing A, and permitting the water above the line to flow back by gravity through the pipe C to the boiler. The water having thus resumed its level, the bucket falls to its former position, moving the counterbalance and lever D, and the latter rising the supply valve is again opened. Should the supply of water be stopped or so reduced that the water evaporates faster than it is supplied to the boiler (the water level being the same in both the cylinder A and the boiler), as the water evaporates the bucket falls with it until the short end of the lever D opens the alarm whistle by means of the connexion. The connexion can be lengthened or adjusted so that an alarm may be given at almost any desired point below the feed line. The gradual increase of whistle sound is such that ample time is given to avoid an alarm, provided water is supplied in proper quantity.

The arrangement we have above described is, as we have said, very simple, and it appears a very promising one, as the system of balanced bucket contained within the vessel A, gives ample power for actuating the supply valve, and the movement of the lever D is not liable to be interfered with by the slight friction of the stuffing-box through which its spindle passes.

Fig. 9 shows another arrangement designed to obviate the loss of power due to pumping against a weighted valve, the arrangement being specially designed for use on marine engines. The regulator is constructed by bolting together two metal discs, with a flexible diaphragm between them In the centre of the diaphragm is a spindle securely fastened, one end of this spindle acting as a guide, the other end extending out through a stuffing-box and supporting the lever upon which the weight hangs, the arrangement being somewhat similar to that of a safety valve. The under side of the flexible disc has communication with the discharge pipe of the pump, through a connecting pipe, in which is placed a check valve I, opening inwards towards the disc. In the spindle of this check valve, a small hole is drilled for the purpose of getting a gradual motion when opening the valve in the steam pipe of a pump, to which it is attached as shown. The top side of the disc is connected to a pipe (in which is formed a siphon) leading either from the steam or water space of any one of the boilers, to obtain the same pressure on both sides of the disc. The pressure in the discharge pipe of the pump against the under side of the diaphragm being greater than that in the boilers, the weight and lever are raised.

The operation is as follows:—Should all the regulator or feed valves and the feed pipes of the boilers become closed, an increased pressure will at once be thrown upon the under side of the flexible disc, and the valve J, in the steam pipe of the pump will be closed, and will remain so as long as the valve remains closed in the feed pipe of the boiler, or as long as the pressure is maintained in the discharge pipe of the pump. But as soon as a feed valve is opened, the pressure being reduced, the weighted lever drops to its position again as fast as the water can pass out through the spindle of the check valve, thereby causing a steady movement of the machine. The valves on the feed pipes can all have a slight lead of opening, and thus allow the pump to move constantly at a slow speed.

In working his regulator Mr. Berryman found much difficulty in getting a proper valve; but eventually he designed that illustrated by Fig. 10, Plate XLI. By a simple arrangement this balanced poppet valve is made to rotate on its seat at each time of its opening, causing a constant and equal wear on all parts of the valve and seat. The fork inside has one prong longer than the other, so that at opening the bearing is on one side of the valve, and this tends to rotate it each time it opens. The fork works between two collars or shoulders which allow the valve to move freely.

The last exhibit we have to notice in the present section is an automatic boiler feeding apparatus devised by MM. Roufosse, Houget, and Teston, of Verviers, and shown on Plate XLI., Fig. 1. By reference to the engraving, it will be seen that the apparatus consists essentially of a cylindrical chamber,

communicating on one side with the boiler, and on the other with a high-level reservoir. It contains two floats of different dimensions, the smaller sliding freely up and down a vertical rod, while the larger is immersed in the water, and kept above its line of flotation alternately. The water from the rseervoir is led by a pipe *c*, through a valve *k*, and falls into the chamber *b*. In rising it carries up the small float *d'*, which sliding along the rod *e'''*, strikes against the lever *e''*, raises it, and thus disengages the lever *e* held at the end by the small pallet *i*. The large float *d* immersed in the water then rises rapidly, and lifts the lever *e*, to which it is attached. The rising of the lever *e* opens the valve *l*, which allows the entry of steam from the boiler, and closes the valve *k*, thus stopping communication between the chamber and the high-level reservoir. The chamber and the boiler are now in equilibrium, and the water flows from the former into the latter, passing through the valves *m* and *o*. This valve *o* is moved by a float *p*, placed in the boiler, and which, according to the variation of water level, closes or opens the valve, so as to permit only the admission of the proper quantity of water.

The small float *d'* follows the water as it descends, until it strikes on a stud fixed at the extremity of the guide rod *e'''*. By its weight it detaches the large float *d*, which in falling again closes the valve *l*, and reopens the valve *k*. The steam in the receiver then escapes into the reservoir, where it becomes condensed, and more water flows into the apparatus. The process just described then recommences. In connexion with the apparatus there is also a counter which indicates the number of times the operation has been repeated, and this affords a means of knowing the exact quantity of water fed into the boiler. We believe that this apparatus has been tested largely, and has given good results. It will be seen from the engraving that the working parts are easily accessible.

CRANES AND HOISTING MACHINERY.

THERE were not a very large number of machines exhibited at Vienna which have to be described in this section, and of those which were shewn but few presented any points of special novelty or interest. America seemed to be unrepresented in hoisting machinery of any kind, as also were Belgium, Switzerland, and several other countries, while France, Italy, the Netherlands, Norway, and Finland, each sent only one machine of any importance. Great Britain, Germany, and Austria, had the most important exhibits, and out of these three countries Great Britain probably stood first.

ENGLAND.

The three portable balance cranes furnished to the British and Austrian commissions by Messrs. Appleby Brothers, of Southwark, were amongst the most useful auxiliary machines in the Exhibition, and, beyond question, greatly expedited the work of arranging the heavy goods in the Machinery Hall. The makers were requested by the commissions just named, to supply three cranes for service at Vienna. They were to be of the same type as those which were formerly placed by the firm at the disposal of the British Commissions in Paris and London. They were accordingly sent to Vienna, but owing to delays in transport, those for the Austrian department were not in operation until the early part of May, but there was then, and for a long time subsequently, plenty of work for them. The three cranes are for 3, 5, and 7 tons respectively, and are of the same general design, the difference being only in proportion. The illustration shows the largest of the three, in which, as in the others, the carriage is cast in one piece, the horns being provided with bearings for the travelling wheels.* The central post is of wrought iron, and the top of the carriage is recessed for a spur wheel fitting on the column, and made fast or

* See Plate 166, Fig. 1.

loose with it, and there is a raised roller path truly turned on the outer edge of the recess. A base plate, fitted with three friction rollers, revolves on the central column, two of the rollers being placed directly below the jib, and one at the back to take the weight of the boiler and tank. The engines are carried on this base plate in a pair of A frames, the feedwater tank and the boiler being placed some distance from the centre of the crane post, and forming a counterbalance to the weight to be lifted. The boiler is vertical, and is fitted with two cross water tubes, which system, although not so economical as the multitubular as regards fuel, works out better in practice, as cranes are so often fed with the worst kind of water. The work is done with a pair of direct-acting steam cylinders placed slightly on the incline, one outside each side frame, the crank pins being fitted into a pair of balanced disc plates. In addition to the usual lifting and turning motions, each crane has a neat arrangement for travelling by steam and for altering the radius of jib by the same agency. The engine shaft between the side frames carries a bevel wheel made fast or loose on the shaft by means of a toothed clutch, for driving an oblique worm shaft gearing into a tangent wheel on the derrick chain barrel for raising or lowering the jib, the worm wheel securely locking the jib in any position. A broad spur wheel is geared on the crank shaft, and works a narrow wheel below it on a weigh shaft, which has a small crank pin at each end equal to the stroke of the slide valves. The narrow wheel can be moved by a hand lever laterally about 4 in. on a spiral feather, thus reversing the valves for running the engines in either direction. This arrangement answers well, and is found to be more durable than a link motion. A pair of spur wheels are placed on the left side of the crank shaft, and which gear into wheels on the countershaft below. One pair of these wheels are of equal, and the other of unequal, diameters, and either pair can be made drivers by means of a double-toothed clutch. Provision is made for working the crane by hand, if necessary, through this shaft, which also carries a set of bevel wheels and double friction cones for driving the slewing and travelling motions. As this shaft has two speeds communicated to it from the engine shaft, it will impart two speeds to the slewing and travelling motions. The motion from this set of wheels is transmitted through a train of wheels to the spur wheel on the column, and which is twice the depth of the pinions gearing into it. The pinions are placed at different heights, so that the slewing pinion clears the pinion driving the travelling gear, and which is fixed. To travel the crane the body is fixed to the carriage, and the wheel, revolving on the crane post, drives the travelling motion. The friction cones are operated by an eccentric lever, and can be thrown in contact while the engine is running, the jib being put in motion gradually without slack. On the cones being reversed they act as a brake, and arrest the motion of the jib. A pinion sliding on a feather in and out of gear, with a spur wheel on the barrel shaft, conveys the lifting motion from the countershaft. This pinion is withdrawn for lowering, and the descent of the load is controlled by a strap brake worked from a foot-lever, which is fitted with a pawl and ratchet, so that the load can be left suspended at any point of its descent. As the slewing motion can be put into action through the cones whilst a load is being raised or lowered, a considerable saving of time is effected. It will be seen that the speeds of working are in direct relation to the loads; as many as 60 or 70 loads may be lifted and turned round in an hour with the quick speed, whilst heavier loads, which necessarily require more time to manipulate, are dealt with at a correspondingly lower speed. The details of construction are well carried out in these cranes, which are well got up, without the superfluous finish too often given to machinery for exhibition.

The cranes have satisfactorily stood the test of the rough work to which they have been subjected.

Messrs. C. Powis and Co., of Millwall, exhibited a 5-ton crane but we are not aware whether it did any work in the Exhibition building. It has two cylinders 6 in. in diameter by 10 in. stroke, and is practically a copy of Messrs. Appleby's crane, although its design is inferior. It runs on a truck on the ordinary 4 ft. 8½ in. gauge, and has raising, slewing, and travelling gear; the jib is of wrought iron. The rollers for taking the pressure run on a conical

instead of a flat path. The boiler is stayed at the top to the engine frame—a wise thing to do. The piston rod head of the engine is somewhat remarkable; it is of brass, and for no visible reason has its guide surface placed far below the pin instead of in a line with it; the fire-door also is very inconveniently situated.

Messrs. J. H. Wilson and Co., of Liverpool, sent a very good 2-ton crane with 12 ft. radius, very similar in arrangement to those above mentioned; it has two cylinders 6 in. by 10 in. (lifting in single gear), and also runs on the ordinary railway gauge.* The travelling gear is worked through a vertical spindle running right through the centre of the pillar, and both axles of the truck are driven simultaneously, instead of only one, as in the other cases. The frame does not work on rollers, however, so that the full bending stress comes on to the pillar. The same firm also exhibited a very complete steam winch, with a pair of cylinders 7 in. in diameter by 12 in. stroke. It has single and double gear and link motion, an overhung drum for winding light weights, &c., a pulley on the engine shaft for driving machinery, and a disc on the drum shaft with a number of holes in it by means of which a deck pump of any stroke from 12 in. to 26 in. can be driven. It has also hand gear, and the spur wheels are all carefully shielded to prevent accidents.

Messrs. Aveling and Porter's combined crane and road locomotive rendered invaluable aid to the British Commission in moving goods, before the opening, as well as after the close of the exhibition. Before the opening, cases too often were delivered at a considerable distance from their proper destination, and not unfrequently on a wrong line of rails, which though not very far off, were yet hopelessly distant (on account of the paucity of sidings and connexions), from the chance of getting them within reach of any usual means of unloading. Messrs. Aveling and Porter's crane is well known, and it is only necessary to say here that the one exhibited, and actively employed, was intended to lift loads up to two tons (a weight often exceeded in practice), that the hoisting chain passes underneath the engine, the jib being at the front end, and that the drum is placed upon the intermediate shaft. The lifting only is done by steam, slewing must be managed by hand, but is of course not often necessary, as the engine can so easily place itself in any required position. The angle of the jib can be altered (but not while any weight is on it) by a simple arrangement of holes in two flat bars which form part of the back stay.

Mr. C. E. de Lorière, of Westminster (whose name, by the way, was not on the machine), exhibited a crane of a somewhat novel design. Its peculiar arrangement seems to have been suggested by that lurking idea that power can be created by multiplying levers, a notion which even in this 19th century has not been entirely got rid of, and the crane is only worth description as a curiosity. On the first shaft (which is turned by hand) are three cranks, set for some reason not 120 deg. apart, but thus ⊥. These cranks work by connecting rods three double-ended horizontal levers, the other and shorter ends of which work (by three more connecting rods) three cranks of correspondingly shorter throw on a second shaft. From this shaft the drum is driven by single or double gear. The inventor or designer of this extraordinary gear apparently forgot or did not know, that precisely the same result would be obtained if the pinion on the second shaft had been placed on the first, and the whole of the connecting rods and levers done away with. By way of adding to the originality of the design, the webs of the ⊥-irons forming the jib are cut away close to the framing, exactly where strength is most needed, and the bar still further weakened by a bolt hole being put through it; the back stay, too, being so placed that if straight it would foul some of the gear, is bent round to clear, with a touching confidence in the rigidity of $\frac{5}{8}$ in. round iron bar.

The only British machine remaining for notice is the patent "combined "steam and hydraulic" travelling crane, which was exhibited by Brown Brothers, and Co., of Rosebank Iron Works, Edinburgh. This crane is

* See Plate 167, Fig. 1.

intended for emptying ships, or doing other work where speed is the great object, and it has therefore been specially and successfully arranged to attain the maximum of speed independent of the bulk or weight which may in this way be added to the crane itself. The system adopted is, in outline, as follows: Beside the boiler, which is of unusual size for the light weight (30 cwt.) the crane is intended to lift, are placed two vertical steam cylinders, 16¼ in. in diameter, and having a maximum stroke of 6 ft. 8 in. The top ends of their piston rods are connected by a crosshead, which is also connected with the piston rod of a water cylinder of the same stroke and about half the diameter, standing between them. The motion of the crosshead is communicated to the lifting chain through a pair of three-sheaved pulley blocks, not, as usual, in such a way as to cause the power to move through six times the space through which the weight moves, and therefore to be only one-sixth as great, but exactly the opposite, to cause the weight to travel six times as fast as the crosshead, and thus to throw a resistance upon the two pistons (neglecting friction) equal to six times the weight to be lifted. The total amount of steam required in the cylinders to do the work is theoretically the same, whether two large cylinders making only one stroke be used, or two small ones making a great number of strokes—it will probably be less in practice, in the former case; but of course in the large cylinders the same amount of steam is required in a very much shorter space of time, and the boiler must be correspondingly larger in order to furnish it. The water cylinder in the centre serves mainly as a regulator, by which the danger of the steam pistons bursting through the top covers (in case of the chain breaking, or of negligence on the part of the driver) is obviated by an ingenious arrangement of self-acting valves. The lowering is also entirely controlled by this water cylinder, which is therefore the brake of the machine. Immediately the lift is completed the steam is exhausted from the cylinders, the load being held in its place by the water cylinder. A smaller steam cylinder, 12 in. diameter and three ft. stroke, placed between the other cylinder and the boiler, is arranged by means of chain tackle to slew the crane very quickly, and a small double cylinder engine, fed with steam by a pipe passing through the centre of the pillar, and fitted with a very ingenious reversing apparatus, placed by itself in the carriage underneath the crane, is provided for the travelling gear. One roller is placed underneath the foot of the jib, running on a conical path on the under carriage. The average time required for lifting, slewing, and lowering a number of times (the load being some hundredweights of rough iron), was as follows: for the lift to the top of the jib (about 16 ft.) 4 seconds, slewing round 180 degrees, 12 to 13 seconds, and lowering the weight to the ground again 2½ and 3 seconds. Some 30 of these cranes are now at work on the quay at Hamburg, to which place also the one that was exhibited has been sent.

France.

In the French department, Messrs. Mabille frères and Amboise had a small roughly made portable crane on the same principle as Dietrich's (to be mentioned presently), but the only machine of importance was the portable crane of Messrs. Bon and Lustremant (Paris), on the Neustadt system. This is a large machine, but is marked only to lift 2,000 kilos., or about 2 tons. The engine has one cylinder only, and hoists, slews, and travels; but the jib can only be raised or lowered through a small distance by hand. The engine power is transmitted to the working gear through three flat-rimmed friction wheels, the lower one being on the engine shaft and the middle one running loose on a pin. By means of a screw and hand wheel, this middle wheel can be thrown at once out of gear, and a brake simultaneously applied to the upper one; the hoisting is done by a return chain passing round a block. The general arrangement of the crane cannot be much praised; there are no rollers underneath the jib foot, the governor is fixed on an over-hung bracket in a place where it is likely to be knocked away, and a large wrought-iron box beam or bracket is placed in front of the jib in a position where it does not appear to be of much use. The workmanship of the machine is, however, better than its design.

GERMANY.

In the German department, Messrs. Dietrich and Co., of Reichshoffen (Elsass-Lothringen), exhibited their hand cranes, two fixed and one made to travel on a railway truck. The two former are for four and six tons respectively, and are made with a large star shaped cast-iron foundation plate, so as to need no masonry foundation. They each have balance weights (that on the travelling crane being adjustable), and have two peculiarities worth noting. First, the jibs are made of wrought iron, of two channel irons of a special section rivetted together, and secondly, they have no drums, the chain being simply made to take half a turn round a pulley with lugs on it, and then allowed to fall down into the chain box underneath. The lugs on the pulley catch the shoulders of each alternate link in the chain, and the chain is kept from falling loose on the under side of it by a guard. This arrangement saves very much in width of the crane, and is very neatly carried out. The machines altogether are well made.

Not entirely belonging to this section, but still necessary to be mentioned here, is a "Hülfswagen," made by Van der Zypen and Charlier, of Deutz. This is a combined crane and carriage, intended to be sent off to the scene of a railway accident, and to be serviceable in clearing the line of encumbrances, lifting fallen carriages, and so on. The crane itself is very neatly made, and is for working by hand only, lifting up to 2½ tons. It has a wrought-iron box jib on Fairbairn's plan.*

The Darmstadt Maschinen-Fabrik und Eisengiesserei showed a conveniently arranged portable steam winch, which being placed on wheels, can be drawn by horses on ordinary roads The boiler, winch, and the whole of the gearing are carried on a frame of channel iron 7 in. deep by 3 in. wide. The boiler is vertical, standing between the two sides of the frame, and is fired from the side. The engine has a single cylinder, vertical and inverted, secured to the boiler at top. The winch (about the construction of which there is nothing special) lies at the front of the machine, and is worked by double gear, all the shafts being supported in brackets on the channel iron frame. The flywheel on the engine shaft has a broad turned rim, so that it can also be used to drive a small centrifugal pump placed on the back of the frame, or other machinery if required.†

Messrs. H. and R. Lamberts, Burtscheid, Aachen, exhibited what should perhaps rather be called a small winding engine than a winch. The engine has two cylinders horizontally placed, and a pinion on the crankshaft gears into a wheel on the drum shaft. The machine is compactly arranged, but some of the gear looks too light for much rough work.

A hand travelling crane for lifting 25 cwt. very neatly arranged was exhibited by the Sächsische Werkzeugmaschinenfabrik (formerly Joh. Zimmermann), of Chemnitz. The drawing, which shows (to a scale of one-tenth) a side elevation, does not require much explanation.‡ The rod with the universal joint, and the worm with the spur wheel, transfers the motion to the drum, the whole gear being fixed to two cast-iron frames which are connected by bolts. These two frames, the width between which may be fixed for each special purpose of the crane, are carried by four rollers running over two rails or bars, which are fastened by means of brackets to the roof, but which allow the rollers to pass them freely, so that the crane may be moved over any length without getting foul of the brackets. These cranes, which can be moved and worked by one man, are much applied on the Continent, and are very convenient for tool and small fitting shops.

Fig. 9, plate 168, is an illustration of a small and compact overhead travelling crane constructed and exhibited by the Werkzeugmaschinenenfabrik Saxonia (formerly Constantin Pfaff), of Chemnitz. The crane runs upon a pair of light rails suspended from the roof of the shop. The motion is transferred from the driving pulley through gearing to the bevel wheels, and thence to the worm which actuates the chain drum. The crane is intended to lift weights up to 2½ tons.

* See Section VIII. † Plate 166, Fig. 2. ‡ See Plate 168, Fig. 8.

The Chemnitzer Maschinenbau Gesellschaft (formerly A. Münnich and Co.) showed a very simple winch for weights up to 4 cwt. It consists simply of two side frames and two spindles, the upper spindle having handles at its ends, and driving the lower one by means of grooved friction gear. The Stettiner Maschinenbau Actien Gesellschaft "Vulcan," Stettin, exhibited a model and drawings of the 40,000-kilogramme (nearly 40 tons) floating shear legs constructed by them for the Imperial German Marine. The shears are placed in a flat-bottomed rectangular vessel with a flush deck. In the centre of the boat is a double-cylinder engine, furnished with steam by a multitubular boiler, and this engine is arranged so that it can do the whole of the work. Two lifting drums are provided (under the deck—one on each side), one to be used for light, and one for heavy, lifts. The two side legs are round in section, but the back leg is square. The mode by which the legs are run out is somewhat similar to that designed by Colonel Sir Andrew Clarke. Two triangular frames are set up on deck, having guides about 20 ft. long up the sides of them furthest away from the front legs. In these guides works a crosshead, to which the bottom of the back leg is attached, and this crosshead is made to be the nut for a long screw lying between the two guides. The engine can be made to work this screw, and according as the crosshead (and with it, of course, the end of the back leg) is moved up or down, the legs are run out or in. This mode of attachment is nearly equivalent to having a back leg of moveable length pivoted on a fixed point.

Of the four overhead travelling cranes which were worked in the Machinery Hall, the two largest were made by Herr Ludwig Stuckenholz, of Wetter-on-the-Ruhr, Westphalia, for the locomotive workshops of the Imperial Royal State Railway, in Vienna.* They are intended to lift 25,000 kilogrammes (about 25 tons), and have been tested with a load of 30,000 kilogrammes. This construction of crane is one which has been adopted by Herr Stuckenholz for the last five years, and during this time he has made a large number of such machines.

The crane is driven by a fast-running rope, the rope driving pulleys lying in a horizontal plane at the bottom of the machine. The apparatus for regulating the tension of the rope is seen in Fig. 3, fixed between a pair of columns. The following are the points claimed as specialities in the construction of the crane:—The winch is fixed at one side of the girders, instead of moving across it, and the hoisting arrangement adopted, causes (as will be seen) the lift always to be in an exactly vertical direction, without the side motion, which is generally found in the ordinary construction. In order to distribute the load better upon the girder the lifting chain passes over two toothed pulleys, one end of it going to one side, and the other to the other, of the girder. No worm wheels are used, on account of the great loss of power by friction which they entail; but in order to gain the advantage of worm gearing, *i.e.* the self-acting holding of the load, a Napier differential brake is used. In order to provide for the three different motions (lifting, traversing the weight, and moving the whole crane along), three sets of bevel wheels are employed, which are put into gear by powerful friction clutches. A spindle running parallel to the main vertical shaft carries three worms, each with a corresponding hand wheel, for the purpose of moving the clutches, and the latter are so arranged that any pair of motions, or all three, can be worked at the same time. No winding drum is used with the winch, but a steel cylinder takes its place, having projections or teeth, upon which the pins of the chain links catch.

The girder is hollow and rectangular in section, open at the bottom, and of wrought-iron plates throughout. It is stiffened inside by gusset stays, and outside by pieces of T iron, and also by angle irons along the bottom edges. The end carriages are also wrought-iron boxes, and have double sides. The span of the crane is 34 ft. 3 in., the depth of the girder in the centre 3 ft. 1½ in., and at the sides 2 ft., the breadth of the girder throughout is 2 ft. 4 in. The distance between the centres of travelling wheels at sides is 7 ft. 4 in.

* See Plate 167, Figs. 2 and 3.

The only other German exhibit of hoisting apparatus of any importance was the trophy of the Duisburger Maschinenbau Actien Gesellschaft, formerly Bechem and Keetman, of Duisburg-on-the-Rhein. This trophy was quite a noticeable object in the centre of the nave, and embraced a large collection of hand winches, chains, pulleys, hooks, jacks, and in fact almost everything connected in any way with lifting. All these were well made, but scarcely call for any special mention.

AUSTRIA.

In the Austrian department the Erste Brünner Maschinen-Fabrik Gesell schaft had a neatly and substantially made winding winch for working by compressed air in mines or other situations where steam could not be conveniently used. The framing of the machine is V-shaped, the cylinders standing vertically at the bottom of the frames, and driving the drums (which are of wood) by single gear only. The main slides are fitted with reversing gear, and have also Rider's expansion valves working behind them. The air is compressed, and forced into an accumulator, by an ordinary horizontal engine and direct-acting air pump. The same firm exhibited another machine of similar construction, but adapted to be worked by steam. Both these machines will be used with round wire rope. They also showed a double-barrelled steam windlass somewhat differently arranged. The side frames are A-shaped, the main shaft running across the tops of them; the two cylinders are placed at the sides of one of the frames, and are connected with the same crankpin. One eccentric works the two slides, the rods having flat spring pieces instead of joints. The drums, which are grooved for the rope, are driven by treble gear, and loose discs running between their flanges are fitted to take the side strain. The Fürst Salm'sche Maschinenfabrik, Blansko, also exhibited a similar double-barrelled treble-geared windlass. In this machine, however, the cylinders are vertical and oscillating; their inner sides work on the trunnion pipes, and their outer sides on centres which can be tightened up. The whole machine is made portable on four small wheels. The frames are substantially made, but the gearing looks rather light.

The most interesting of the Austrian exhibits, although only a small machine, was perhaps the winding winch* exhibited by the Maschinenbau Actien Gesellschaft (formerly Danek and Co.), of Prague, whose large collection of heavy machinery attracted so much attention. As regards its construction and use it is in fact simply a small winding engine. The most notable feature in it is the arrangement for reversing the engines, an invention of Herr Vincenz Danek's, and in its general construction it is so made that it can be easily transported by horses or otherwise along steep roads, or in other places, such as often occur where such machines are required, and where the carriage of heavy castings would be difficult or impracticable.

In the engravings Fig. 1 represents a side elevation (with drums removed) and a section through the guides; Fig. 2 a section through the drums; Fig. 3 a plan of the whole, partly in section; Fig. 4 a cross section of the bedplate through the guides; Fig. 5 a cross section of the bedplate close to the cylinder; Fig. 6 an end elevation of the whole, with section of one cylinder and valve chest; and Fig. 7 sections through the valve itself.

The machine has two cylinders 7 in. in diameter by 10 in. stroke, placed one on each side, and with one of them the feed pump (worked from the crosshead) is cast. The front cylinder cover forms part of the bedplate, which has also the guides and the plummer block in one piece with it. The piston rod head (cast iron) is made with a web extending down from each side of the double eye (*see* Fig. 4) leaving an open space between, and through this space the upper guide bar passes, the bedplate itself forming the lower guide. This is a very simple and efficient arrangement for small engines; it would be improved however by the addition of a brass liner under the foot of the head, or some other arrangement by which wear on the foot or the guide could be taken up without depressing the centre of the piston rod. Plain discs are provided instead of cranks, and the brake is placed on the periphery of one of these.

* See Plate 168, Figs. 1 to 7.

The driving pinion is placed on the centre of the engine shaft, and gears with a spur wheel cast with the drum centre. To make up the framing of the drum, four castings are used, besides the wooden rings, viz., two ends, A and D, and two centre pieces B and C. Each end casting is secured to the half of the centre nearest it by a flanged coupling. The end A is quite plain, and is keyed on to the shaft. The centre piece B, is also keyed on to the shaft, and has cast with it the spur wheel above referred to. C and D are not keyed to the shaft; C is driven from B by a ring through bolts of which two are seen in the section, Fig. 3 and D is driven through the bolts in the coupling. Each of the six arms of D has a boss close to the flange with a hole through it (Fig. 2), and the little bracket E is so placed that any of these bosses can be brought opposite it. The object of this arrangement is to adjust the length of the rope before commencing to work, in order to do which the bolts connecting C to B are taken out, and the drum, C D, held fast by a bar put through E and one of the holes in the bosses just referred to. The drum, A B, can be driven by itself, and the free part of the rope (one end of which is, of course, connected with A B, and the other held fast by C D) made exactly the desired length. The machine rests entirely on timber framework, and the plummer blocks of the drum shaft are made separate from the bedplates, so that the diameter of the drums may be made always to suit the special requirements of each case.

The reversing gear is shown in Figs. 3, 6, and 7. Each valve is worked by an eccentric in the usual manner. The valve chests are cylindrical chambers of about the same size as the cylinders, and bored out. The valves themselves have faces turned to the radius of chest and divided into three sections (Fig. 6), *a*, *b*, and *c*, either one of which can be brought over the cylinder ports by moving the hand lever, *h*, which turns the valve spindles by means of the connecting rods, *k*, and levers, *l*. Of the three faces, *b* is perfectly plain and solid, and when brought over the cylinder ports (as shown in the drawing), it acts as a stop valve, entirely preventing access of steam to the cylinders. The sections of the faces, *a* and *c*, are seen in Fig. 7. They are so arranged that when *a* is opposite the ports the engines shall move forward, and when *c* is opposite them they shall move backward. Fig. 7 shows clearly the way in which the reversing takes place, the two faces being shown for the same position of valve, and the course of the steam being indicated by the arrows. This ingenious arrangement allows any desired lap to be given to the valves, and is particularly well adapted for small engines and for situations where repairs to gearing may be difficult to execute. The blank face *b*, is a necessary part of the arrangement, but it is also useful in making the slide valve act also as a stop valve. There appears to be no reason why this reversing valve should not come into extended use.

The same firm had also in their pavilion a 13-ton travelling crane of 44 ft. 6 in. span, which runs on rails on the floor level. The cross girders are of wrought iron and I-shaped, and supported at each end on wrought-iron vertical frames. Each of these side frames are A-shaped, the legs consisting of flat box beams stiffened in the space between by latticework. The winch is worked from below by light endless chains.

The not unfrequent accidents due to overloading cranes, by either breaking or overturning them, led the engineers of the North-Western Railway of Austria to attach registering scales to the cranes under their control, in order that by inspection the men could tell whether they kept within the proper limits. This addition, however, was not found to be successful. In many cases the men could not read the scale, in others the trouble was too great, while in several instances the register was broken by the application of an excessive load upon the crane.

This method was, therefore, abandoned, and after some experimenting the detail illustrated,* was adopted, by which it became impossible to lift any weight heavier than that for which the crane is designed. The end of the lifting chain, instead of being fastened to a fixed link at the end of the jib, is attached to a link hung to a cross bar, at each end of which is a vertical bolt rising through a casting in the head of the jib, and carried by a pair of

* See Plate 166, Figs. 3, 4, and 5.

volute springs. The arrangement is clearly shown in the drawing. These bolts can be adjusted with the greatest nicety, and the strength of the springs is made to correspond with the maximum load that the crane has to lift. Fastened to each of the bolts is a triangular block, with a feather at the back, serving as a guide, and moving in a groove, and with a number of V grooves in the front or inclined side (Figs. 2 and 3). The sheave, over which the chain passes, is indented to a pitch corresponding to that of the chain itself, and on either side, and forming a part of it, it is formed with a number of V grooves corresponding to those in the blocks above mentioned. So long, therefore, as the weights placed upon the crane do not exceed the set limit, these blocks are not moved, but if a heavier load is added, the springs are compressed, and the brake blocks coming in contact with the sheave lock this latter, and prevent all motion.

We may add that this detail is regarded very favourably upon the North-Western Railway of Austria.

A Pesth firm (Sigmondy Vilmos) exhibited a treble-geared hand winch to be used for winding purposes with flat wire rope. Herr Körösi, of Gratz, is the maker of the two small travelling cranes to which reference has already been made. They have wrought-iron girders, are worked by a fast-running hemp rope, and hoist with a return chain and block. The chain used is of the plate link type. Herr C. Weichum, of Vienna, exhibited a model of a crane in which the whole of the movements are made on balls.† For travelling on rails the balls are carried in a kind of endless chain, which prevents them dropping out; all the bearings on and under the pillar, &c., for the slewing motion, are also fitted with rings of balls.

HYDRAULIC MOTORS.

Industry, rapidly progressing and extending, turns, year after year, to more useful account the power of water as offered by nature, and the demand for rationally constructed hydraulic motors is consequently so great, that a special interest attaches to the moderately large collection of these machines shown at the Vienna Exhibition. Science and practice work hand in hand in order to fulfil the demand to which we have referred, and the hydraulic motors at Vienna showed in many respects improvements, when compared with those which we saw at the last great Paris Exhibition.

America.

Commencing our survey at the western end of the Machinery Hall, we found in the American department the Capron Water-wheel Manufacturing Company of Hudson, New York, exhibiting a turbine on Capron's patent, with vertical shaft, outer admission, eccentric casing, and without guide blades. The buckets are provided at the discharge ends with peculiarly constructed funnel-like enlargements. The regulation of the water is effected by a rectangular throttle valve placed in the admission pipe. The construction of this turbine leaves, no doubt, much to be desired, but it is exceedingly simple in all its parts, and possesses one great advantage, namely, that all these parts are easily accessible.

Great Britain.

In the English department we found a small partial turbine on Girard's system exhibited by Messrs. Gwynne and Co., of London. The guide wheel is provided with buckets on two opposite quadrants only, whilst the two other quadrants are closed. A movable disc of a shape corresponding with the closed quadrants can be moved by means of rack and pinion over the open guides, and thus by means of this segmental disc the number of guides into which the water is admitted may be regulated. The buckets of the turbine wheel are largely widened towards the bottom in order to make the angle of discharge as small as possible.

* See Plate 168, Figs. 6 to 9.

SWITZERLAND.

Switzerland, rich with water power and industry, exhibited, in relation to the size of the country, a good number of turbines. Messrs. T. Rieter and Co., of Winterthur, showed drawings and several parts of large hydraulic and turbine works, which were in course of erection during the period of the exhibition, or which had already been built. These were :—

1. The turbines at the Rhinefell, near Schaffhausen, published some years ago in an excellent work by Gronauer.

2. Large turbine works executed in 1871 for the Société Générale Suisse des Eaux et Forêts à Fribourg.

3. The large turbines in course of erection at Bellegarde, on the French frontier, where the rivers Rhône and Valerine unite. These latter are five turbines on Jonval's system, with suction tube, for a height of fall of 13 metres (42 ft. 8 in.), and a consumption of water of 5,188 litres (1,141 gallons) per second. The level of the tail water rises sometimes 4 metres (13 ft. 1 in.), whilst that of the water at the top rises only 2·5 metres (8 ft. $2\frac{6}{16}$ in.), whence the height of fall is reduced at high water to about 11 metres (36 ft.). Each turbine has an outside diameter of 2·49 metres (8 ft. 2 in.), and two casings, measuring, radially, 0·2 metres ($7\frac{7}{8}$ in.), and 0·15 metres ($5\frac{7}{8}$ in.). The number of guides is 24 and 22, whilst the wheel has 26 and 24 buckets. The thickness of the buckets is 20 millimetres ($\frac{4}{5}$ in.), and the wheels are cast in one piece; the pressure of the pivot is counterbalanced in the manner adopted in Zuppinger's turbines, about which we shall speak hereafter. The Bellegarde turbines make 90 revolutions per minute, and transfer the motion by means of bevel wheels to the wire-rope pulleys, these latter being 5·5 metres (18 ft.) diameter, and making 70 revolutions per minute.

The large frames carrying these rope pulleys were exhibited together, the power being transmitted from each turbine by means of two ropes of 35 millimetres ($1\frac{3}{8}$ in.) diameter, over large distances. There was also exhibited an auxiliary turbine, which could be stopped or started by means of a governor driven by the main turbines, and which was intended for opening the sluices of the latter.

The engineering works and foundry of St. Georgen, near St. Gallen, showed two well-designed and executed partial turbines, for considerable heights of fall and small quantities of water. The arrangement of these turbines is the reverse of that of Fourneyron's; the water enters from below through a tube into the guide wheel, passes sideways through the latter, and thus drives the turbine wheel, which is largely widened at the bottom. The admission of the water is regulated by means of segmental sluices, which allow the entrance of the water into a certain number of buckets only, the buckets, which are open, being equally distributed over two quadrants opposite each other, so that the pressure on the pivot produced by the discharge of the water is counterbalanced, whence the pivot has to carry only the weight of the turbine wheel, the shafts, and the wheel for transmitting the power. An indicator connected with the hand gear for working the sluices shows how many of the buckets are open. The bearing of the pivot (which is upon the cover of the pipe admitting the water from below), the pivot, and the guide bush—of considerable length—are made of the best cast iron. The wrought-iron bucket plates of the pressure wheel are cast in; the void spaces produced by the passage of the water through the wheel are partly done away with by air holes drilled at the back of each bucket into the two rims of the wheel. The water enters each bucket as a compact stream, and presses against the front side without touching the back; but the water will certainly not be discharged from the wheel in an equally compact state, as during its transit through the buckets, its admixture with the air admitted through the air holes, cannot be prevented. The construction of these turbines allows of nearly equally favourable efforts being obtained with the maximum consumption of water, and with a much less quantity.

Socin and Wick, of Basle, exhibited two Girard turbines with the water admitted from the top, one of these being for a moderate height and moderate

quantity of water, whilst the other is for a high fall and a small quantity of water. The latter is provided with vertical sluices, which alter the section of the guide buckets, these sluices being fastened in groups of three to vertical drawbars, which can be raised and lowered above their glands in the cover of the casing by a horizontal ring, movable round the axis of the turbine. This ring is provided with teeth on the inside, and on turning it by means of suitable gear, an alteration in the position of the sluices is produced. The regulation of the water in the other turbine is effected by the turning of a segmental sluice. The buckets of the wheels of both the turbines are enlarged radially towards the under side.

Messrs. Roy and Co. of Vevey, exhibited highly interesting models of turbines, in which the water tanks were partly made of glass plates, thus giving the opportunity of observing the discharge of the water from the different wheels. Messrs. Roy and Co. built all their turbines on Girard's system, and, as the exhibitors state, with a free discharge, that is to say, the wheels are never allowed to work in the tail water, the effect being in such a case considerably reduced. With small heights of fall and large quantities of water this system leads either to the very questionable so-called syphon turbine with air-pump, or to the screw or river turbine, which, of course, is admissible, but certainly very expensive. Messrs. Roy and Co. exhibited four different constructions of their turbines, namely, one with mantle for large and medium quantities of water, and for a height of fall of from 3 to 15 metres (10 to 49 ft.); another turbine with horizontal axis for medium and small quantities of water, and for medium and large heights of fall; a third turbine with water chamber for large quantities of water and for heights of fall up to 10 ft; and, finally, a screw turbine. The section of the guide buckets of these turbines, with the exception of the last one, can be altered, and the admission of the water may thus be regulated, whilst the screw turbine worked with the least difference in the level of the water, but showed plainly how expensive such an arrangement is, and that its adoption is justified only in few cases.

Messrs. Escher, Wyss, and Co., of Zurich, exhibited a small partial turbine with horizontal axis, and outside admission of the water to be used in connexion with the water works of cities for small power and for small industrial works.

We should also include amongst the Swiss exhibits of hydraulic motors the very simple form of water-pressure engine designed by Mr. A. Schmid, of Zurich, and which we illustrate on Plate CLXIX., Figs. 1, 2, and 3. The particular engine shown by our illustration has a 7 in. cylinder with 9 in. stroke, and it is calculated to develop 5 effective horse-power for each 100 ft. of head of water with which it is worked. Referring to the engraving, it will be seen that the cylinder is oscillating, and that the face to which the passages from each end of the cylinder open, is curved to an arc of a circle struck from the centre line of the trunnions. This face is beneath the cylinder, and bears upon a correspondingly formed concave face, having in it three ports, of which that in the centre communicates with the supply pipe, and the two outer ones with the escape or exhaust. It will be readily understood, from an inspection of the section, how, as the cylinder oscillates, the water is alternately admitted to, and exhausted from, each end of the cylinder.

Referring to the side elevation and plan, it will be seen that the trunnions on the cylinder work in bearings formed in a pair of levers having their fulcra at one end on the engine frame, and connected at the other end by a cross piece, as shown. A bolt—connected by a pin and double eye at its lower end to the engine frame—passes up through this cross piece, and exerts a downward pull upon it through the intervention of an india-rubber washer. By means of the nuts on this bolt the pressure can be regulated to just the amount sufficient to keep what we may call the valve faces in water-tight contact. The trunnion bearings are also adjustable for wear, as shown in the side elevation.

An air vessel is provided on the supply pipe to absorb any shocks which would otherwise be caused by variations in the speed of flow through that

pipe, and it is found that in practice these engines run with great smoothness. An engine of this class, with 5 in. stroke, has been run most satisfactorily at 200 revolutions per minute. As regards the duty obtained, we may quote the following extract from a report made by Professor Kronauer, of the Polytechnic School at Zurich. He says: "As a member of the jury charged with "the trial of twelve water motors (five cylinder engines and seven turbines) "of different constructions, I can state that the engine of Mr. Schmid has "surpassed all the others in regard of the per-centage of duty and of "simplicity of construction, the trials, which have been made with the "greatest care and accuracy, having given a useful effect of 89 per cent." The engine is, as the professors justly remarks, of very simple construction, and it is due to the builders to say that the proportions and general design are excellent. We have no doubt that these engines will prove very useful motors in a large number of cases.

France.

France was represented in this branch of industry by a turbine, and by a complete model of a turbine driving a flour mill with six sets of stones, by Messrs. Bethouart and Brault. The model was one already known from its having appeared at former exhibitions, while the turbine was one on Jonval's system, with a circular division, that is to say, two turbines separated by a partition were united in one wheel. The driving wheel was cast in one piece, and was conically widened towards the bottom, and with full admission of the water can work in the tail water. The regulation of the water supply was effected by two semi-annular strips of india-rubber, which, when developed, cover the whole of the guide wheel, but which can be rolled up by cones moved by means of suitable wheels, and which when so rolled up uncover a larger or smaller number of buckets. In order to work this turbine with even a small quantity of water with good effect, the inner ring of the turbine may be closed by plates placed upon the guide wheel.

Germany.

Germany showed two complete working exhibits of considerable extent, these representing well executed hydraulic motors and pumps of recent construction. The first of these exhibits was that by Messrs. Nagel and Kaemp, of Hamburg, in the German section of the Machinery Hall. The group contained altogether:

a. Four turbines, namely:

1. A partial turbine, with moveable guide bucket apparatus, and an outside diameter of 2,100 millimetres (6 ft. 10·67 in.).
2. A turbine of 930 millimetres (36·6 in.) outside diameter, with full delivery for the water and a complete arrangement of sluices.
3. A turbine of 1,100 millimetres (3 ft. 7·3 in.) outside diameter, with partial delivery for the water, and with horizontal axis and adjustable sliding valve.
4. A turbine of 550 millimetres (1 ft. 9⅝ in.) outside diameter, with partial delivery for the water, horizontal axis, movable guides, and regulator for buckets.

b. Two centrifugal pumps, namely:

5. Centrifugal pump of 500 millimetres (19·68 in.) outside diameter, with horizontal axis, outside guides, and eccentric casing.
6. Centrifugal pump of 450 millimetres (17·71 in.) outside diameter, vertical axis, and outside guides.

c. Three examples of water-elevating apparatus, namely:

7. Apparatus for emptying chambers of turbines.
8. Water-ejecting apparatus for charging of centrifugal pump No. 6.
9. Steam-ejecting apparatus for charging of centrifugal pump No. 5.

We shall commence our description of these exhibits with the only machine not set to work, namely the turbine with partial delivery for the water, movable guide bucket apparatus, and an outside diameter of 2,100 millimetres (6 ft. 10·67 in.). Turbines with full delivery for the water, that

is to say, with a delivery distributed over the whole circumference of the wheel, are generally applied with advantage for moderate heights of fall, whilst turbines with a partial delivery of the water are best used for a great height of fall, because the former would become for great heights of fall too small, and would have to run too fast, whilst the latter cannot satisfactorily be applied for small heights of fall on account of being too large, and therefore too expensive. The best known and most extensively applied kind of turbines, with partial delivery for the water, are the tangential wheels, in which the water is admitted from the outside and delivered from the inside. All Messrs. Nagel and Kaemp's turbines, with partial delivery, have, however, an inner admission and an outside delivery. In tangential wheels the water approaches the axis of the turbine by passing through the guides and the buckets, working thus in opposition to the centrifugal force; whilst in Messrs. Nagel and Kaemp's turbines, with partial delivery, the water follows the direction of the centrifugal force.

We publish on Plate CLXIX., Fig. 4, an engraving of the outside view of Messrs. Nagel and Kaemp's turbine with partial delivery. The water passes through the iron admission pipe from below into the guides, which surround annularly the circular part of the mouth of the pipe, and which can be moved round the latter by means of wheel gearing, in such a manner that, according to the requirements, more or less guides are opened for the admission of the water. The admission chamber, covered at the top with a bell, is provided at the circumference with two rectangular ports of equal section, and placed diametrically opposite to each other. If the annular guide apparatus occupies its extreme position in one direction, these ports are entirely closed, while by turning the apparatus to the left, an equal number of guides on each side are placed simultaneously before the opened ports, thus admitting the water through two, four, six, eight, &c., guides, as may be required. Nothing can be said against this arrangement from a theoretical point of view, and it appears to offer great practical advantages. In the first place it is certainly of advantage to be able to observe the delivery of the water at the guide wheel, whilst further, all working parts are accessible on account of the water being admitted from below, whence the guide wheel, with the shaft, may be lifted in a most convenient manner, and the bearing and pin may be at once examined and taken out. The symmetrical arrangement of the guide apparatus prevents an unequal pressure of the water upon the shaft of the turbine, whilst the moving of the guide apparatus by means of wheel gear appears to be simple and easy.

The next example, a turbine (see Figs. 5 and 6, Plate CLXIX.,) with full delivery of the water and an outside diameter of 930 millimetres (36·6 in.) is built according to the old system of Fourneyron, inasmuch as guide and bucket wheel are in the same horizontal plane, that is to say, the guide wheel is inside the bucket wheel. The admission of the water, however, into the guide wheel takes place below, and the turbine is provided with an adjusting arrangement for the simultaneous regulation of all the guides and buckets, whence the turbine works with a nearly constant percentage of effect, independent of the quantity of water admitted. A practical advantage of the admission of the water into the guide wheel from below, and of the application of the inner guide wheel, is the complete counterbalancing of the pin of the turbine, as the pressure of the top water acting under the wheel disc may be used for counterbalancing the weight of the turbine wheel and axle.* Further advantages are the easy access to all parts of the guide and bucket wheel, after the latter has been lifted off, the free and always visible delivery of the water from the guide wheel into the chambers of the turbine, and finally the application of these turbines for a very low height of fall, as stated by the exhibitors, who say that one of these turbines works with a height of fall of 6 in. only, and drives a mill with one stone.

The arrangement by means of which all the guides and buckets may be simultaneously fixed in a perfectly equal position as regards height, is very

* In turbines of the ordinary Henschel-Jonval type, where the guide wheel is placed above the bucket wheel, the reverse takes place, as is known. The pressure of the water has to be added to the weight of the turbine wheel, and the pin is loaded doubly.

interesting, as each position secures, from a theoretical point of view, the correct delivery and guidance of the water, and the correct passage of all sections from the guide to the bucket wheel, whilst we shall be able to point out some practical advantages. All the guides are firmly fixed to a cast-iron plate which closes the guides at the top, and which is called by Messrs. Nagel and Kaemp the "guide plate;" this plate is raised and lowered with the guides by the adjusting arrangement, whilst both the plate and the guides are guided vertically in the lower compartment between guide brackets, which form the lower partitions for the guide buckets. The changing of the position of the "guide plate" produces, therefore, also an alteration in the position of the guide wheel. In a corresponding manner the alteration in the position of the bucket wheel is effected as follows: Between each pair of buckets is fitted a plate which can be moved vertically up and down. All these plates are placed at the same height, and they are fastened at the inside to a common ring, and at the outside to a common bell; whilst the inner ring is connected with the bell by means of bolts which project through the "guide plate." The bell, which is guided by the axle of the turbine, serves as a cover or protection of that part of the bucket wheel into which the water is not admitted. The raising and lowering is effected by the same mechanism which moves the guide plate, that is to say, by means of a shaft, with which both the bell and the guide plate are connected by cranks and rods. In the same manner as the guide plate alters and determines the height of the guides, the bell fixes the height of the buckets, so that turning the shaft above-mentioned alters simultaneously and in an exactly equal manner the height of the guide and bucket wheel. The position of the guide plate and of the bell can be altered during the working of the turbine, as well as during the time the latter is put out of gear. We should mention here the ingenious arrangement adopted for greasing the pin of the turbine, which is kept always surrounded by oil. This pin is not fixed to the axis of the turbine, but to the lower guide for the movable guide plate, whilst the metal bearing is fastened to the hollow axis of the turbine. Pin and bearing are surrounded by an oil-box, which is closed towards the outside by a seal from the tail water. The oil is introduced through the hollow shaft from the top and through a tube into the oil box, in the upper part of which the oil accumulates, and is pressed constantly against the frictional surfaces by the water outside and below. All dirt or particles produced by the wear of the pin and the bearing fall off, whence the surface of contact between pin and bearing remain always clean.

The turbine of 1,100 millimetres (43·30in.) outside diameter, with partial delivery, horizontal axle and adjustable valve, as shown by Figs. 7 and 8, Plate CLXIX., has been designed, according to the statement of the exhibitors, for practical requirements and not for theoretical advantages. It is specially built for the colonies, and for distant countries where no skilled workmen for its erection are to be found, for which reason the turbine is sent out entirely put together, so that it can be placed at once on the foundations and set to work. The Figs. 7 and 8, Plate CLXIX., represent this turbine, the horizontal axle of which is carried on a cast-iron frame. In this construction the water is also admitted into the bucket wheel from the inner periphery through a number of guides, which can be opened or shut by a slide valve, common to all, and placed over the guides. This turbine has been designed for great height of fall, and the exhibitors state, as an example, that one of these tribunes has been applied, in Hungary, to a height of fall of 140 ft., producing an effect of 35 horse power, and weighing only 18 cwt.

The turbine (see Figs. 9 and 10, Plate CLXIX.) of 550 millimetres (21·69 in.) outside diameter, with partial delivery, horizontal axle, movable guide wheel apparatus, and radial adjustment of buckets is, with respect to the arrangement of the guide wheel apparatus, similar to the one first described, from which it differs, however, by having the axis arranged horizontally, and by the annular guide wheel apparatus being provided, not with diametrically and symmetrically arranged ports opposite to each other, but with guides placed on one side only, whence a one-sided pressure upon the axle of the turbine is produced. As the turbine is, however, of but

small dimensions, this pressure does not appear to be of any consequence. The horizontal shaft has also in this case been adopted merely for the practical convenience of erection and fixing. We should not omit to mention here an arrangement connected with this turbine and based upon an original and ingenious idea, namely, that of using the direction of the water coming from the bucket wheel for the regulation of the turbine. We have already several times mentioned that all the turbines by Messrs. Nagel and Kaemp are designed in such a manner that the delivery of the water from the bucket wheel can always be observed during the working of the turbine. Messrs. Nagel and Kaemp claim this arrangement as a great advantage for their construction, and we must admit that this original and ingenious arrangement of bucket adjustment justifies their claim. It is well known that in a turbine on Fourneyron's system the water will, when the maximum useful effect is obtained, pass *radially* from the bucket wheel, or nearly *vertically* in a turbine of the Henschel-Jonval system. If, however, a turbine does not work with the maximum effect, the water is not delivered radially or vertically respectively, but at an acute or obtuse angle. Messrs. Nagel and Kaemp have turned to account this change in the direction of the discharged water for the self-acting regulation of the turbine, by placing an apparatus with wings in the current of the discharged water; this apparatus places itself always in the direction of this current, and acts also in these positions on that of the sliding sluices.

In the turbine exhibited at Vienna, the regulating or adjusting apparatus is fixed in the following manner:—The bucket wheel of the turbine is surrounded by a number of radial buckets, which form together another wheel, moving freely on the axis of the turbine, and being connected with the guide wheel by several spur wheels, so arranged that any angular movement of the regulating wheel produces also a proportionate angular movement of the guide wheel apparatus. During the normal working of the turbine above mentioned, the water passes radially out of the bucket wheel and hence passes also between the radial guides of the regulating wheel without exerting any side pressure, whence the regulating wheel remains stationary, while the turbine is running. If now the normal speed is interrupted, and the turbine begins suddenly to run too fast, the water passes with an acute angle from the bucket wheel into the regulating wheel, pressing thus against one side of the radial guides of the latter, and turning it therefore to the left. This movement is transferred by the spur wheels mentioned above, to the guide wheel apparatus, in such a manner that the admission of the water is altered until the normal speed has been obtained again, that is to say, until the water is again discharged radially from the bucket wheel, when the regulating wheel becomes once more stationary. A similar effect is produced when the speed of the turbine is suddenly diminished, in consequence of which the water is discharged under an obtuse angle, and turns the regulating wheel to the right, producing thus an opening of the guides. The action of this apparatus was shown on the turbine exhibited at Vienna in a very clear and thorough manner, by the use of a brake by means of which the normal speed of the turbine could be interrupted.

The two pumps shown by Messrs. Nagel and Kaemp were a centrifugal pump 500 millimetres (19·68 in.) outside diameter, with horizontal axis, outside guides, and eccentric casing, and one 450 millimetres (17·71 in.) outside diameter, with vertical axis, and outside guides. As regards the first-mentioned centrifugal pump, we may state that it was distinguished from centrifugal pumps of the ordinary type chiefly by a proportionately large casing, and by the adoption of bearings movable in an horizontal direction; it was also without any foot valve. The large casing is required on account of the outside guides, which are considered by the exhibitors to be indispensable. In order to fill the suction pipes and the casing of the pump of which we are speaking, Messrs. Nagel and Kaemp had fitted to it a steam-jet exhauster, about which we shall have more to say further on.

The second centrifugal pump above mentioned as having a vertical axis, was submerged in the upper reservoir at the makers' stand, and was provided with a contrivance called a "water ejecting apparatus," instead of the bottom valve. We ourselves have a strong objection to centrifugal pumps with

vertical spindles, and we believe that the circumstances are exceedingly rare which will justify their adoption.

Passing now to the jet pumps as they may be called, we have to speak of an apparatus for emptying chambers of turbines, and a water-jet pump and a steam-jet exhauster for the charging of centrifugal pumps. The first of these arrangements is a contrivance for raising water by utilising a jet furnished by an existing fall. This apparatus, which has been invented by the exhibitors (and an illustration of which, showing its application for general purposes, we give on Plate CLXIX., Fig. 11), was used at Vienna for emptying the brick-built chamber containing the partial turbine, an illustration of which we give on Plate CLXIX., Fig. 4. As regards the application of this apparatus at Vienna, we may state that the water was taken from the upper to the lower reservoir (see illustrations on Plate CLXX.), through a system of conically converging and diverging pipes, and at the narrowest point of this system, that is to say, where the convergence and divergence met, and where a negative pressure existed, the system of pipes communicated with the chamber of the turbine to be emptied by a suction pipe of 4 in. inside diameter. A few minutes were sufficient for the apparatus to empty the chamber of the turbine, the bottom of which was 4 ft. below the level of the tail water. The exhibitors have applied this apparatus to a variety of purposes.

Passing now to the steam ejecting apparatus, we may state that, as has been previously mentioned, it has been constructed for filling centrifugal pumps, whence it has had to be rendered efficient for all heights of suction for which centrifugal pumps can be used. In the example exhibited the opening of the steam jet was only one-eighth inch diameter, but this is according to the statement of the exhibitors sufficient, even for the largest centrifugal pumps, for long suction pipes, and for suction heights of 20 ft. and more. The steam jet enters into a conically diverging pipe, the narrowest point of which communicates with the highest point of the casing of the pump. At this narrowest point, however, the steam jet produces an exhaustion and draws the air from the casing of the pump and the suction pipes, the delivery pipes being meanwhile shut off by a float. The apparatus is very simple, and may be be used for all sizes of pumps; it was patented in England in 1868, but so far as we are aware has been little used in this country. As an example of the usefulness of this apparatus, the exhibitors state that centrifugal pumps with suction pipes several hundreds of feet long, and with a suction lift of more than 20 ft., have had the air exhausted from them and been filled with water exclusively by such an apparatus, the pumps not being provided with bottom valves.

In all cases now where water pressure instead of steam pressure is at hand, Messrs. Nagel and Kaemp effect the filling of the centrifugal pumps by means of a water-jet exhauster, which differs from the steam-jet exhauster, described above, simply by the substitution of an of course stronger jet of water for the steam jet. The water-jet apparatus shown at the Vienna Exhibition was used for filling the vertical centrifugal pump mentioned above, the water of the upper reservoir being used for working the apparatus, whilst the vacuum produced by the latter, shown by a vacuum gauge, was exceedingly good, although the head of water available was $2\frac{1}{2}$ metres (8 ft. $2\frac{1}{8}$ in.) only. Altogether the result was highly satisfactory.

For the better explanation of the particulars given above, there are given on Plate CLXX. illustrations of the exhibits of Messrs. Nagel and Kaemp, which represent a full view of the whole group. In the illustrations E is the centrifugal pump with eccentric casing, which was driven from the shafting under the floor of the Machinery Hall; this pump took the water from the lower reservoir, raised it through the funnel-like tube 5 metres (16 ft. $4\frac{7}{8}$ in.) high, whence it fell 1 metre (3 ft. $3\frac{3}{8}$ in.) into the upper reservoir. B is the turbine, 930 millimetres (36·61 in.) outside diameter, with full delivery for the water, and a complete arrangement of sluices. C is the vertical centrifugal pump driven by the turbine B; this pump also takes the water from the lower reservoir, and forces it through another funnel-shaped tube into the upper reservoir, altogether through a height of 5 metres. The water supplied by the two centrifugal pumps was used for driving the turbine B, the available head being 4 metres (13 ft. $1\frac{1}{2}$ in.).

The available cubic contents of the upper reservoir, up to the level of the semicircular overflow weirs, amounted, after deducting the two funnel-shaped tubes, to exactly 801·44 cubic feet, and this reservoir was filled by means of the centrifugal pump E in exactly 101 seconds, whence this pump delivered, at its normal speed, and to a height of 5 metres, $\frac{801 \cdot 44}{101} = 7 \cdot 935$ cubic feet of water per second. This quantity fell over the funnel-shaped end of the tube shown in Fig. 12, Plate CLXIX., the effective diameter of which was D = 1·055 metre, or 41·54 in., whilst the measured head of the discharge $h_1 = 0 \cdot 089$ metre, or 3·5 in.

The quantity of water Q_1, flowing per second over overflows of this kind, is found by the well-known formula:

$$Q_1 = \tfrac{2}{3} \mu b h_1 \sqrt{2 g h_1}$$

in which μ represents the coefficient of discharge, b the width, or in this case the circumference D, of the overflow, this width being in the present instance

$D \pi = 3 \cdot 315$ metres, or 10·876 ft.

$h_1 = 3 \cdot 5$ in., or 0·2917 ft., and

$2g = 64 \cdot 4$ ft. for the acceleration due to gravity.

According to this formula we get, in the present case:

$$7 \cdot 935 = \tfrac{2}{3} \mu \times 10 \cdot 876 \times 0 \cdot 292 \sqrt{64 \cdot 4 \times 0 \cdot 292},$$

whence $\frac{2}{3} \mu = 0 \cdot 576$, which shows that, for such overflows of 1·055 metre diameter, the coefficient of outflow is almost exactly the same as that found by Eytelwein for well rounded-off weirs.

For the further calculations, we shall use the following symbols:—

1. For the centrifugal pump with eccentric casing:

$Q_1 = 7 \cdot 935$ = the quantity of water per second in cubic feet.

$H_1 = 16 \cdot 4$ ft. (5 metres) = total height through which the water is lifted.

$b = D \pi = 10 \cdot 876$ ft. circumference of overflow.

$h_1 = 0 \cdot 292$ ft. effective head.

η_1 = percentage of effect.

N_1 = effective working power of the pump.

Therefore, taking the weight of water at 62·4 lbs. per cubic foot,—

$$N_1 = \frac{1}{\eta} \times \frac{62 \cdot 4 \times 60\, Q_1\, H_1}{33{,}000} \text{ horse power.}$$

2. For the centrifugal pump:

Q_2 = quantity of water per second in cubic feet.

$H_2 = 16 \cdot 4$ ft. = total height through which the water is raised.

$b = D \pi = 10 \cdot 876$ ft. width of the overflow.

$h_2 = 0 \cdot 2362$ ft. effective head.

η_2 = percentage of effect.

N_2 = effective working power of the pump, therefore

$$N_2 = \frac{1}{\eta_2} \times \frac{62 \cdot 4 \times 60\, Q_2\, H_2}{33{,}000} \text{ horse power.}$$

3. For the turbine (B):

$Q_3 = Q_1 + Q_2$ = quantity of water per second in cubic feet.

$H_3 = 13 \cdot 12$ ft. (4 metres) = total available height of fall.

η_3 = percentage of effect.

N_3 = effective working power, therefore

$$N_3 = \eta_3 \times \frac{62 \cdot 4 \times 60\, Q_3\, H_3}{33{,}000} \text{ horse power.}$$

The whole effective power developed by the turbine having been used in driving the centrifugal pump with vertical spindle, we find that

$N_3 = N_2$, or by substitution that

$$\eta_3 \frac{62 \cdot 4 \times 60\, Q_3\, H_3}{33{,}000} = \frac{1}{\eta_2} \frac{62 \cdot 4 \times 60\, Q_2\, H_2}{33{,}000}; \text{ but}$$

$Q_3 = Q_1 + Q_2$, and $H_3 = 13 \cdot 12$ ft.; $H_2 = 16 \cdot 4$ ft., whence

$$\eta_3 \frac{62 \cdot 4 \times 60 \times 13 \cdot 12\, (Q_1 + Q_2)}{33{,}000} = \frac{1}{\eta_2} \frac{62 \cdot 4 \times 60 \times 16 \cdot 4\, Q_2}{33{,}000}$$

or,

$$\eta_3 \eta_2 = \frac{5}{4} \frac{Q_2}{Q_1 + Q_2}$$

We also find under the same conditions and for the case where the total amount of water ($Q_1 + Q_2$) supplied by the two centrifugal pumps has been exclusively used for the working of the turbine (B), that the height h_2 of the effective head at the top of the funnel-shaped tube for the pump C is:

$$h_2 = 0{\cdot}2362 \text{ ft.},$$

whence

$$Q_2 = \tfrac{2}{3}\mu\, b\, h_2 \sqrt{2\, g\, h_2}$$
$$= 0{\cdot}576 \times 10{\cdot}876 \times 0{\cdot}2362 \sqrt{64{\cdot}4 \times 0{\cdot}2362},$$

therefore $Q_2 = 5{\cdot}77$ cubic feet per second.

The same result is obtained in a shorter manner by division.

$$\frac{Q_1}{Q_2} = \frac{\tfrac{2}{3}\mu\, b\, h_1 \sqrt{2\, g\, h}}{\tfrac{2}{3}\mu\, b\, h_2 \sqrt{2\, g\, h_2}} = \frac{h_1 \sqrt{h_1}}{h_2 \sqrt{h_2}};$$

in this equation the relative values of Q_1 and Q_2 are expressed simply by the corresponding heights of head h_1 and h_2, whence a very convenient calculation of the quantities of water by means of the easily measured heights h_1 and h_2 is obtained. From the above equation we get;

$$Q_2 = Q_1 \frac{h_2 \sqrt{h_2}}{h_1 \sqrt{h_1}} = 7{\cdot}935 \; \frac{0{\cdot}2362 \sqrt{0{\cdot}2362}}{0{\cdot}292 \sqrt{0{\cdot}292}} = 5{\cdot}77$$

cubic feet per second. Substituting the values of Q_1 and Q_2 into the formula given above,

$$\eta_3\, \eta_2 = \frac{5}{4} \frac{Q_2}{Q_1 + Q_2}$$

we get

$$\eta_3\, \eta_2 = \frac{5}{4} \frac{5{\cdot}77}{7{\cdot}935 + 5{\cdot}77}$$

or

$$\eta_3\, \eta_2 = 0{\cdot}52,$$

that is to say, the real effect produced by the turbine and by the vertical centrifugal pump together is 52 per cent. of the theoretical power of the water which is available for the turbine, or the percentage of effect from the gross power of the turbine water to the power represented by the effect of the pump, is 52 per cent. This, it must be admitted, is a very favourable result, for supposing that the percentage of effect of the turbine is *equal* to that of the vertical centrifugal pump, we get

$$\eta_3 = \eta_2 = \sqrt{0{\cdot}52} = 0{\cdot}72,$$

that is to to say, both turbine and centrifugal pump work with a useful effect of 72 per cent. It may be, however, safely admitted that the turbine produces a greater percentage of effect than the centrifugal pump, and if we suppose, for example, and in accordance with the greater probability that

$$\eta_3 = 0{\cdot}75, \text{ we get } \eta_3 = \frac{52 \times 100}{75} = 69{\cdot}3 \text{ per cent.}$$

that is to say, the turbine apparently gives 75 per cent., and the vertical centrifugal pump nearly 70 per cent. of useful effect.

It should be borne in mind that this result is obtained with a turbine of small dimensions, which represents a power of but 15 horses, and the sluices of which for the admission of the water were but two-thirds open. Altogether Messrs. Nagel and Kaemp's exhibits of hydraulic motors and machinery were of a most interesting character.

Having described the collection of turbines exhibited by Messrs. Nagel and Kaemp, of Hamburg, we have now to report on the second of the large exhibits of hydraulic motors at Vienna, namely, that comprising the water wheels of Mr. D. Straub, of Geislingen, which were erected, as every one who has visited the exhibition will recollect, outside the Machinery Hall, near the eastern end. Mr. Straub's exhibit of hydraulic motors consisted of a tangential wheel and two other differently constructed wheels, one a breast wheel on Zuppinger's principle and the other a wheel on Millot's system with internal admission, illustrations of both which we publish on Plate CLXXI., while of the latter wheel we also give a section on Plate CLXXII. The wheels were in motion during the greater part of the Exhibition, the water

being raised by five centrifugal pumps, to which it again flowed back through culverts, after having acted on the wheels.

Before describing these exhibits we may state briefly the leading principles by which the design of water wheels should be governed. Whether the water acts chiefly by its weight or by its impulse, it is always necessary in order to reduce as much as possible the loss of effect, that the jet of water when first coming into contact with the buckets should not strike against but glide along them. Realising this condition, and considering that the resultant of the velocity of the jet of water and of the negative surface velocity of the wheel should be parallel to the tangent of the bucket-curve, it is obvious that this tangent must occupy a position within certain limits, as the surface velocity is given. After the water has been thus delivered to the wheel with the smallest possible loss of head, it should be allowed to escape along the tail race freely and without much waste of power. The most usual way of accomplishing this is by providing a sudden drop at the end of the breast into the tail race, the wheel being then not in contact with the tail water. It cannot be denied that this arrangement is one of the most simple for effecting the free discharge of the water, but at the same time it is a disadvantageous one with respect to the performance of the wheel, as the whole height due to this sudden drop is lost. In order to get over this difficulty, the tail race is sometimes made to join the breast tangentially, and in order to prevent the tail water from acting objectionably as back water upon the buckets of the wheel, its velocity is made equal to the circumferential velocity of the wheel. In order to prevent the water from being lifted by the ascending buckets, the latter should be of such a shape that the tangent to the curve of the bucket assumes a vertical direction at the point in which this curve cuts the surface of the tail water. This condition is fulfilled if the shape of the bucket, as far as it is immersed in the water, is the evolute of the circle, the centre of which is the centre of the wheel, and the periphery of which touches the surface of the tail water. In a wheel constructed in this manner, it is obvious that every part of the bucket is moving in a vertical direction when cutting the surface of the water in the tail race, whence disregarding the friction between the water and wheel, no loss of head occurs whilst the water is being discharged. There are thus conditions concerning the admission and the discharge of the water which are dependent upon each other, but that the fulfilment of the one set introduces obstacles to the fulfilment of the other, may be clearly seen from an observation of wheels on Sagbien's system.

In his wheels exhibited at Vienna Mr. Straub endeavoured to improve the construction as much as possible, and he bestowed special care on the design of the curve of the buckets, whence he got a larger circumferential velocity. However, the manner in which the deepening of the tail race of the breast wheel is effected, as shown in the vertical section of that wheel on Plate CLXXI., does not appear to be one capable of being readily justified, and does not even effect the object which leads to the adoption of the sudden drop so frequently used, the water surface not being lowered. Besides, the mode of deepening adopted by Mr. Straub has a detrimental influence, as it causes the tail water to move with a less velocity than the wheel, whence the buckets have to overcome a resistance which increases with the square of the difference between the surface velocity of the wheel and the speed of the water moving through the suddenly enlarged area of the tail race.

The breast wheel exhibited at Vienna, and illustrated on Plate CLXXI., Figs. 1 and 2, was of a type suitable for a height of fall of from 0·3 to 4 metres (say 1 ft. to 13 ft.), and for a quantity of water per second of from 0·3 to 6 cubic metres (10·6 to 212 cubic feet). Mr. Straub states that the real effect of these wheels is between 65 and 75 per cent. The wheel exhibited at Vienna was, with the exception of the buckets and the two bosses, made entirely of wrought iron, the object being to make the wheel less heavy, and to reduce as much as possible the loss of power through friction between gudgeons and bearings. The principal dimensions of the wheels are as follows: Diameter over all, 16 ft. $8\frac{3}{4}$ in.; width, 5 ft. $10\frac{7}{8}$ in.; diameter inside buckets, 9 ft. $7\frac{1}{8}$ in. The curves of the buckets are struck with a radius of 3 ft. 3 in., the centres being situated on a circle touching the outer edges of the floats. The shaft is 8 in. in diameter through one of the bosses, and $6\frac{7}{8}$ in. through the other; while

the bearings are 7½ in. diameter by 9½ in. long, and 6½ in. diameter by 7⅝ in. long respectively. The shaft carries at one end a spur wheel 11 ft. 0¼ in. diameter, and having 160 teeth, this wheel gearing into another 3 ft. 0⅜ in. diameter, and having 44 teeth. The two other wheels, which transmit the motion to the shafting, are 6 ft. 10⅝ in. and 2 ft. 10¼ in. diameter, and have 140 and 58 teeth respectively. All the details of this wheel, as will be seen from our illustration, are worked out exceedingly well. The regulating sluice delivers the water above its upper edge, which is rounded off in order to avoid contraction and irregularities in the motion of the jet. In our illustrations the sluice is shown full open.

The second water wheel exhibited by Mr. Straub at Vienna, and also illustrated on Plate CLXXI., Figs. 3 and 4, as well as on Plate CLXXII., Fig. 1, represents the system known by the name of Millot's, and is characterised by the internal admission of the water. This system illustrates another endeavour to get over the difficulty of the relation existing between the delivery of the water to and its discharge from a wheel of ordinary construction, a difficulty which is especially felt when the level in the tail race is very variable. In this wheel of Mr. Straub, however, this dependency of the inlet upon the discharge or *vice versâ* is entirely eliminated, and one part of the bucket may be formed in accordance with the conditions for a correct admission, whilst the other part may be shaped according to the rules for a proper discharge of the water. It cannot be denied that the first cost of such an arrangement is greater than that of a wheel of the ordinary construction, but it is urged that the final results obtained with such a wheel are also much in excess of what is generally expected. Mr. Straub claims for a wheel of this kind, and for a height of fall of 3 metres (9 ft. 10 in.), and a quantity of water of from 0·1 to 0·7 cubic metre (3·5 to 24·7 cubic feet) per second, a useful effect of as much as 88 per cent. We cannot, however, help regarding this performance as somewhat over estimated. As regards the design of this wheel, we may finally state that both Mr. Straub and Mr. Millot claim to be the inventors, but it appears to be difficult to decide to whom this right belongs. The wheel shown at Vienna had 54 buckets, and its internal and external diameters were 13 ft. 10½ in. and 18 ft. 5⅞ in. respectively. Its width was 6 ft. 11 in., and it was worked at a speed of five revolutions per minute, the head being 9 ft. 7¾ in., and the water supply 15¼ cubic feet per second. The shaft was 7⅝ in. diameter through the wheel bosses, and the bearings were 5⅞ in. diameter by 9⅜ in long, and 5⅜ in. diameter by 8¼ in. long respectively, the bearing next the spur wheel being, of course, the larger of the two. The spur wheel fixed on the main shaft was 11 ft. 0¼ in. diameter, with 160 teeth, and drove another wheel 3 ft. diameter.

Of the tangential wheel exhibited by Mr. Straub, we cannot say much in praise, as it did not work well at Vienna, although perhaps the whole fault did not lie in the design of the wheel. These tangential wheels may, according to Mr. Straub's statement, be adopted for a height of fall from 15 to 200 metres (49 ft. to 657 ft.), and for a quantity of water varying from 0·01 to 2 cubic metres (·035 to 70.6 cubic feet) per second, giving a real effect of about 70 per cent. This latter fact we must consider doubtful.

The tangential wheel exhibited at Vienna was for a height of fall of 50 metres (164 ft.), and represented a power of 200 horses. A great advantage of this wheel consists in a very conveniently arranged regulating apparatus, which worked very well, and which prevents the action of the wheel from being much disturbed by incrustation, as is sometimes the case with turbines.

We found in the German department two other important exhibits of hydraulic motors; the one being the model of a Henschel-Jonval turbine, of 1,200 horse-power, exhibited by the Augsburg Maschinen-Fabrik, and of which we shall speak directly, whilst the other exhibit was a set of detail drawings of turbines and water wheels by Mr. Walter Zuppinger, of Ravensburg, in Wurtemberg. These drawings showed: 1st, an over-shot water wheel, for a height of fall of 9·3 metres (30 ft. 6 in.), and a consumption of water of from 400 to 800 litres per second, stated to give, with 80 per cent. (?) efficiency, an effect of 80 horses. The wheel has to work in back water of 1·2 metre (3 ft. 11¼ in.). 2nd, a tangential wheel, for 15·7 metres

height of fall with a consumption of from 81 to 162 litres of water per second, giving, with 70 per cent. efficiency, a power of 200 horses; there was nothing new in this construction, and the drawing did not show the most important matter, the shape of the buckets; 3rd, a low breast water wheel for a height of fall, of 3·3 metres (10 ft. 10 in.), with a consumption of water of from 1,215 to 2,430 litres, giving thus, with 70 per cent. (?) efficiency, a power of 120 horses. The wheel is said to still work well with 1·5 metre (4 ft. 10 in.) back water. 4th, a turbine on Jonval's system for great height of fall, with relieving apparatus for the pivot. With a height of fall of 10·5 metres (3 ft. 5·3 in.), and a consumption of 3,000 litres (105·9 cub. ft.) per second, this turbine is stated to give a power of 315 horses. These motors are all well designed, and have all been executed, but we are inclined to think that the effects, as stated by the exhibitor, are rather over-estimated.

The Maschinenfabrik Augsburg, of Augsburg, Bavaria—a firm founded in 1840, and at present employing about 700 hands—exhibited at Vienna a well-executed model of a large turbine, constructed by them in 1867 for the Kränholm-Manufactur-Narva, near St. Petersburg, a good idea of the actual size of the motor being given by the exhibition also of a full-sized model of one of the main bevel wheels and first motion shaft with the coupling forged on. The works which this turbine assists in driving comprise a cotton mill, with 239,692 spindles, and weaving sheds containing 1,647 looms; and until 1867 the power for driving them was supplied by four water wheels of 500 horse power, and two turbines of 450 horse power each, built by the Maschinenfabrik Augsburg. In 1867, however, one of a pair of water wheels, placed side by side, broke down, and as a substitute for these two wheels the 1,200 horse power turbine was constructed.

The turbine above mentioned, of which we give views on Plates CLXXII. and CLXXIII., is on the Henschel-Jonval system, and works with a height of fall of 7·62 metres, or 25 ft., while the quantity of water used is 16·14 cubic metres, or 570 cubic feet per second. The speed is 50 revolutions per minute, and the efficiency of the turbine is stated to be 75 per cent., the effective work done being nearly 1,200 horse power. The wheel is 12 ft. 1½ in. in diameter, and the buckets are made of wrought-iron plates, cast into the wheel and surrounded by a wrought-iron ring. The buckets of the guide wheel are also of wrought iron, but the encircling ring is of cast iron.

The casing of the turbine is 3·94 metres (= 12 ft. 11 in.) in diameter, and consists of five rings, each made in two parts, the second ring carrying the bearing for the axis of the turbine, whilst the lower ring is supported by eight brackets surrounded by an annular sluice. This sluice is counter-balanced, and can be raised by suitable hand gear, as shown in our engraving, while a main sluice valve is also provided for entirely shutting off the water if required. The two horizontal tubes placed through the casing of the turbine act as supports for the footstep bearing of the turbine shaft, and allow of the lubrication of this bearing by an oil tube, arranged as shown. They are also of such size that access to the bearing may be had through them. The height from the bottom ring to the top of the turbine shaft is 38 ft. and the shaft is of wrought iron, and 1 ft. 3¾ in. in diameter. The bevel wheels, by which the motion is taken off, are 12 ft. in diameter, and each is made in two parts bolted together, as shown. The total weight of the turbine is 14 tons.

Austria.

In Austria we found two exhibitors of hydraulic motors. Mr. P. Fischer, of Vienna, exhibited a so-called "Franzis" turbine, with guide and wheel vertically adjustable during the working, and, further, the drawing of an improved Fourneyron turbine with outside admission, similar to the construction introduced by Messrs. Nagel and Kaemp, of Hamburg. Mr. Fischer stated that the turbines constructed by him will have a real effect of from 80 to 85 per cent., whilst other turbines will give from 60 to 70 per cent., only! We once saw a water wheel advertised to give an efficiency of 120 per cent. (!), so that Mr. Fischer's modest assertions have been outdone.

The second Austrian exhibit of hydraulic motors was that by Messrs. Fischer Brothers, of Wiener-Neustadt, who exhibited three turbines, two of which were constructed on the Franzis system, in which the buckets are

shut by turning over the outside part of the guides, each of which, moving simply round a pin, is pressed against the lower part of the following bucket. The pins carry each a lever, which, touching a projection on a toothed rim during the turning of the latter, shut the buckets one after the other. The construction does not look promising, vacuous spaces amounting to one-fourth of the section of the guides being produced by the shutting of the buckets. One of these turbines is a small high-pressure one in an eccentric casing, whilst the other is for low pressures. Besides these two turbines, Messrs. Fischer Brothers exhibited a partial turbine with internal admission and outside widening of the guide wheel, and with air holes in the rim; this turbine appeared to be heavy in its details, and at the point of admission of the water the contraction had not been taken into account.

The branch house established at Baden, near Vienna, by Messrs. Escher, Wyss, & Co., of Zurich, exhibited a small turbine for using the water of water-works; this turbine is similar in construction to the one exhibited by the chief works, and already mentioned by us.

Russia.

Lastly in the Russian department of the Machinery Hall we found two drawings and one model of an improved Fourneyron turbine exhibited by Professor J. Thime, of St. Petersburg. The improvements are limited to the application of a suction pipe, the real value of which is still a matter of opinion. Whilst some consider that the suction pipe acts correctly, others state that the air contained in the water is set free, and expands at the upper part of the pipe, thus reducing the effective height of fall, if the great velocity of the discharged water does not carry off the air. The exhibitor effects the regulation of the water by means of an intermediate guide plate fixed in the guide wheel itself, and fastened to the circular sluices applied already by Fourneyron, and arranged to be worked by a simple mechanism during the running of the turbine.

AGRICULTURAL MACHINERY.

Steam Cultivation.

How was it, that the Vienna Exhibition, so enormously rich in every kind of human produce, and especially in every class of engineering works, had so little to show in a special branch which has generally displayed itself prominently on former occasions? The question was frequently asked and never satisfactorily answered. Why were there no steam ploughs? There certainly was an imposing display of Messrs. Fowler's double-engine tackle of the largest type, and there were the well-known implements of Messrs. Howard. There were a few models belonging to Messrs. Barford and Perkins, and there was an Italian tackle of antediluvian proportions. But what about Messrs. Fiskin, Ramsomes, Garrett, Burrell, Robey, Coleman, persevering Mr. Hayes, and Father Smith? who had all, at one time or another, betaken themselves to the fields, and, cheerfully or otherwise, turned a furrow by steam. Where was M. Zoy from Nancy, and M. Gavignan, from Paris? Was there no new name to be recorded, as usually happened on former occasions, bringing forth an exceptionally self-moving anchor or a conservative snatchblock, which held on for dear life in the trial-field? Why did not the Americans, with their world-whipping ingenuity, show at last to Europe how they do it on the other side of the water? Was steam ploughing being abandoned, as once stated in a serious and scientific foreign periodical, in consequence of the invention and tremendous success of Pirie's two-furrow horse plough?

Not quite. But a certain lack of exhibition enterprise, or rather of new men and new ideas in the branch referred to, could not help striking the attention of the observer, and could not wholly be explained away by the distance of England from Vienna, and by the cumbrous nature of the exhibits. Till now the international shows of the world had given a remarkably com-

plete and instructive picture of the rise and gradual development of the invention. At the first Exhibition of 1851, in London, the only thing in the shape of steam ploughs which could be found, were a few bold schemes on paper, the most prominent being a French double-engine tackle, which then was considered about the wildest plan conceivable. The question apparently lived then entirely in the world of ideas. But in 1856, at Paris, these ideas had already taken shape. There appeared Mr. Fowler with one of the original roundadout tackles, and with the first form of what afterwards became his clip-drum set—the implement being worked by a self-moving engine and anchor, and an endless rope. Between 1856 and 1862, these two main systems developed themselves, and were shown at London in 1862, in Fowler's clip-drum and Howard's roundabout tackles, both of which had reached (barring trifling details) their final form. But in the same year, the search for novel and improved systems being in full swing, Mr. Savory (through Messrs. Garrett and Sons) and Messrs. Fowler built both their first double-engine tackles, the latter introducing a system which, at the Paris show of 1867, had gained in its main features its present development and a practical importance for the whole question of steam cultivation, which a few years before could scarcely be anticipated. Parallel with the growth of these few practical forms of steam ploughing apparatus, there was evident during the whole period from 1856-67, a profuse activity, resulting in innumerable trials, experiments, and partially successful starts of new forms and principles, which all, more or less, dropped out of sight again after a short period of existence, but giving for the time to exhibitions the sanguine life of hopeful competition, always so amusing to spectators and full of interesting information to the initiated.

At Vienna there was nothing new in principle, scarcely much improvement in details. Is it that the practically possible forms of steam ploughing machinery, based on wire-rope traction, are really exhausted? Has that exuberant flow of new ideas, characteristic to the first stage of every important invention ceased, so as to permit the settling down of acquired experience into really permanent practical forms? Looking at the same time at the increasing commercial success of steam-ploughing all over the world, one is inclined to think that this is the case, and that the want of new and striking exhibits in steam cultivation, of new names of exhibitors, and of many of the old ones, is explained by the fact that we have reached the end of a period in its history: that engines and implements are now successfully produced, which perform the work they are intended to perform, which are adapted to the hands to which they have to be committed, and that it is now, at least for the moment, the commercial development, the practical introduction, and the adaptation to varying local circumstances, which will be the main business and duty of the active and persevering pioneers of steam cultivation.

Thus despite all, the Vienna Exhibition, like its predecessors, fairly represented the present state of the speciality under consideration. The old champions of steam ploughing, Messrs. John Fowler and Co., exhibited a set of their imposing 20 horse power machinery with implements complete, which excited naturally enough considerable attention by the very size of the different objects. The ordinary form of the engine has so often been described on different occasions that it is scarcely necessary to do so now, especially as since the Paris Exhibition, it has been altered solely, although considerably, in details. The steam engine proper has been turned round on the top of the boiler, so that now the cylinder is at the smoke-box end, thus permitting the steam to be taken from the drier portion of the steam space, and to dispense with the bevel gear and slanting shaft, which formerly communicated the motion of the crank to the hind wheels. The cylinders are steam jacketted, being combined in one casting with a spacious steam dome, which carries the safety valve. The introduction, to a very large extent, of single-cylinder engines, has been tried and found exceedingly successful, showing a considerable saving of fuel. The increased difficulty of handling them, as compared with two cylinder ones, has been found to be trifling, as with the present position of the flywheel, the driver is able to move it slightly by hand, without leaving

his place, whenever the engine sticks on its centres. The horn-plates of the firebox are elongated, and used as supports of the bearings of crank shaft and road-gear shafts, thus dispensing with the cumbrous cast-iron brackets formerly required, and not only lightening and simplifying the engine, but saving at the same time the boiler from undue strains arising between the different shafts. The hind wheels are now exclusively moved by spur gearing, whilst a "double-speed pinion" is always applied, so as to facilitate the movement of the tackle for greater distances. The road wheels themselves are made broader, and extra rings are employed, where the ground is particularly soft, so as further to increase the bearing surface of their circumference. The coiling gear has been improved and strengthened by the forked shape of the coiling lever, and more powerful and well protected wheels for the cam movement. All through the engine cast iron has been displaced by cast steel, even to the extent of employing steel winding drums, of which two splendid specimens were exhibited, whilst also most of the shafts, formerly wrought iron, are now made of this stronger and lighter material.

These improvements have gradually increased the effective strength of the engine, and have raised the working pressure of steam from 80 lb. to 100 lb. or 120 lb., whilst at the same time a greater degree of expansion is used, all tending to the employment of larger but still more economical machinery. Whilst, therefore, at Paris 14 horse power engines were considered the largest which could be employed with advantage, a number of 30 horse power apparatus have since been made, and 20 horse power tackles are becoming quite an ordinary and much-preferred size in districts which are specially adapted for steam ploughing. (See Plate 232, Fig. 1.)

Thus the tackle exhibited at Vienna is the fourth apparatus of the same kind, which one of the largest landed proprietors of Austria, the Archduke Albrecht, is now using on his estates in Hungary. There were a few specialities about it, though, which may shortly be mentioned. The boilers were arranged for using peat as a fuel, of which the Archduke possesses large quantities near some of his farms. The peat is of a peculiarly suitable kind, requiring nothing but an enlarged fire-box, a very ready admission of air, and a commodious arrangement for conveying the light but surprisingly bulky fuel to the stoker. Trials made since the close of the Exhibition have proved that the material is well adapted for the intended purpose.

Of implements, Messrs. Fowler exhibited two balance ploughs, one of four furrows, for deep work up to 16 in., with Kent breasts, the other for lighter work, 6 in. to 12 in. deep, with a mould board much in use in Austria and Germany for every kind of work (see Plate 232, Figs. 2, 3). The former implement was also provided with a set of skifes and breasts, for ploughing in long manure, an improvement much required by continental farmers. It is done by attaching a set of ploughs of the original Flemish pattern—in its improved form in Germany called the "Wanzleben" plough, in Austria the "Ruchadlo"—to very high skifes, so as to permit the straw to pass freely underneath the main frame of the implement. It was highly amusing to see the pleasure and satisfaction with which not only continental farmers, but also men of science, doctors, and professors, saw their own national form of mould-board attached to the largest English implements in the Exhibition; and there is no doubt that for certain soils, especially the well and deeply-cultivated lands of the sugar beet-growing districts of Prussia, the short hollow mould-board, so much differing from the ordinary English shape, is preferable for completely turning over the sod with the least amount of mechanical labour.

There were besides two other implements well known now in England: an 11-tine turning cultivator, and, based on the same mechanical principle, what Messrs. Fowler, unjustly, we believe, call a turning harrow (see Plate 232, Figs. 4, 5). It is, in fact, a light cultivator, 16 ft. broad, worked as their turning cultivators with regard to the steering, lifting, and turning, but consisting of three separately suspended and articulated frames, which adapt themselves to the unevenness of the ground, a most essential point in implements of such exceptional width.

Finally there was a beet-root lifter, also an implement specially designed for continental use, being a turning cultivator with three tines (see Plate 232,

Fig. 6). These tines, set apart about 3 ft. from each other, are provided with broad, rather flat points, and pass, at a considerable depth, through every alternate row of beets, loosening and lifting the beets on each side without damaging their roots, an operation which saves a considerable amount of manual labour in dry seasons, besides permitting the beets to be taken out unbroken, and preparing the land for its first subsequent cultivation.

Outside the show grounds, but in direct connexion with the Exhibition, on the estate of Baron von Hopfen, at Gutenhof, Messrs. J. Fowler and Co. showed a 14 horse-power tackle with a five-furrow light plough, a three-furrow deep plough, a seven-tine turning cultivator, and a balance cultivator for very deep work. The tackle was kept at work from the end of May to the end of October, going over about 1,200 acres of land, which were partly cultivated but mostly ploughed. Visitors to the Exhibition found thus a ready opportunity of seeing steam ploughing in regular operation, of which they availed themselves, especially towards the end of the season, in great numbers. It may be mentioned that the tackle had not one breakage during the whole time, excepting shares and cultivator points. Of these a considerable quantity were used in consequence of the extraordinary hard state of the land during the summer months, which actually and completely stopped the ordinary agricultural operations during the early part of last autumn in south-eastern Europe The construction of the engines and implements of this apparatus does not call for any special notice.

Messrs. J. and F. Howard, in connexion with an excellent show of other agricultural implements, exhibited a winding windlass on two wheels, with snatch-block, claw anchors, and sheaves, representing their ordinary and well-known roundabout tackle. It was a pity that the Vienna Exhibition was rather too early to indicate the latest movement in this class of steam ploughing apparatus, although perhaps for purposes of continental trade it was just as well. In these countries steam ploughing will only be employed for the present on estates, many times larger than the ordinary English farm, and under circumstances which make animal labour still comparatively much cheaper than here. Continental farmers will therefore look for extraordinary quantities of work done, or for extraordinary quality, done cheaply, besides having to insist on the least possible amount of skilled labour. The peculiar circumstances which constantly force this class of tackle before the English public are really wanting on the continent. There, as amply proved by many failures of former, and the surprising success of the last three or four years, only the most powerful double-engine tackles succeeded in exciting and satisfying a real and substantial demand for steam cultivation.

Of implements Messrs. Howard showed their four-furrow plough, constructed on the principle of modified balance implements, the two halves being disconnected and turning on different centres, but held together by chains, which wind themselves on eccentric cams or chain-pulley segments. This arrangement, although necessarily somewhat more cumbrous and complicated than the ordinary balance plough, has, for light and shallow work, the decided advantage of keeping the implement more steadily in the ground, as the portion of the frame which is actually working has a considerable leverage over the frame, which is carried in the air. On the other hand, in doing deep work it is more difficult to lift the implement out and turn it at the headlands, as, standing on three wheels, it cannot be thrown into position as readily as a two-wheeled implement, held up and handled by the ploughman at the tail end.

Messrs. Howards' ordinary five-tine cultivator on four wheels, moving backward and forward without turning, proves still the same capital implement it always has been, if not made too large, so as to reduce its somewhat limited steering power. It is too well known to require any description. Much more interesting would it have been to see Messrs. Howards' new turning cultivator at work, which, as an intermediate implement between Messrs. Fowlers' large and heavy and Mr. Smith's small and light cultivators, has been before the public some time, without, we believe, showing its practical value by actual experiments at any of the late exhibitions. In turning round, one of the hind wheels, running back on a kind of shoe, raises itself and lifts the tines partially out of the ground, thus facilitating the turning. But also in this cultivator,

with the pulling rope attached close to the front steering wheel, the steering power, so essential in implements of this class, appears scarcely sufficiently provided for.

Messrs. Barford and Perkins showed only some models; one representing their plough, a light balance implement, with a rigid frame on two wheels, to which the ploughs are attached, being a very close imitation indeed of Fiskin's original patent. There also was a model of Campain's anchor, which is the peculiar feature in Messrs. Barford and Perkins's roundabout tackle—a very good idea, if employed on suitable land, but, like all self-moving anchors, not suitable for every kind of soil and season, nor to the heavy pulls which are unavoidable in steam cultivation on a a larger scale. In a commercial sense it was perhaps as well, for the reasons above stated, that this active and enterprising firm did not go to the expense of exhibiting a full-sized tackle of their own at Vienna.

Even Messrs. J. Fowler and Co. felt called upon to exhibit a model of a roundabout tackle. Why, we could not ascertain. The windlass stands on four wheels—the two additional wagon wheels being the great feature, we believe, of the movement lately originated—and had two vertical drums. Two self-moving anchors are moved by the strain of the pulling plough rope as in Campain's, but held back by a tail rope unwinding from a small drum. To visitors of the last Smithfield show it need scarcely be pointed out that the windlass question appears to have recently assumed a new and more encouraging aspect.

But the triumph and glory of the roundabout system were not attained by England. Signor Zangirolamo, of Adria, in the province of Rovigo, Italy, "assisted by Professor Cavour E. Giordano, at Ferrara," have achieved it. There was no mistake about the intention of these two distinguished foreigners. The machinery filled a considerable space in one of the Italian back yards. It was meant to be a roundabout tackle. It was one. There was a windlass with two vertical drums on two wheels; there was a profuse quantity of anchors, snatchblocks, and rope porters, and two implements, one a one-furrow, the other a two-furrow plough, which both looked very much as if they wished to become balance implements in time. Speaking seriously for a moment, which is difficult, the whole thing looked very much like some patent drawing of the times when steam ploughing was done on paper exclusively. Whatever induced Signor Zangirolamo to get the assistance of Professor Giordano, or Professor Giordano to assist Signor Zangirolamo in the construction of these cruel instruments, we cannot conceive; why they were shipped to Vienna, except it was to get them out of their native country and to spite the once hated Tedescos, nobody could explain, But that they were sent to the public trial field at Siebenbrunn, to be forthwith broken to pieces, showed an amount of courage and earnestness on the part of the exhibitors, which really was beyond all praise. They will fight another day and do great things yet.

This is all that Vienna showed in steam ploughing machinery. It would be a great mistake to suppose, that the interest of the public was correspondingly small. Quite the contrary. The eastern countries are on an average much better adapted to steam cultivation in many respects, than England, France, or the greater part of Germany. The large proprietors in these countries are fully alive to the fact, and eager to avail themselves of the facilities, which they possess in an eminent degree. But there are no doubt in many cases formidable difficulties to overcome. There is sometimes the question of fuel, sometimes that of water, there are the unmanageably large tracts of land which make it difficult to invest considerable sums in the cultivation of a limited area; there is the generally low state of the present quality of cultivation, which prevents the majority from believing in the advantages of a more thorough though at first more costly system of working the land; and there are the varieties of soils, of climate, and of crops, which require special treatment and special implements. These are all difficulties, which have to be studied carefully, and by which even the best and most thorough English champion ploughman will be beaten, if he is not prepared to deal with them according to circumstances.

We understand that the Vienna Exhibition has contributed comparatively little to direct and immediate business for manufacturers of steam-ploughing machinery. This could scarcely be considered surprising. But we believe it has done its duty, more fully in this than in many other departments, in informing and enlightening the future buyers and users of steam-ploughing machinery as well as those who have to prepare for and meet the growing demand under circumstances so widely different from those in England.

Tillage Implements.—Ploughs.

In that highly important section of the Vienna Exhibition devoted to the show of agricultural machinery, there was no more interesting or varied portion than that formed by the implements for tillage. They were so numerous, and so much originality of design, whether in general construction, or minute detail, was to be found in the collection formed by every nation exhibiting, that the consideration of this section of the agricultural implements merits more close attention than the casual observer would be disposed to accord to it. It was especially worthy of note too, that while some of the foreign makers copied English detail, in the ploughs exhibited, home makers, or at least the most conspicuous of them, have gathered ideas, and adapted them from foreign practice, have in short, carried to a higher stage of perfection, the primitive ploughs of the great corn-growing districts of Europe, and which have been in use since time immemorial. It is different with the other implements, for although many novelties in design were to be found in the Eastern Agricultural Hall, yet copies of English harrows, hoes, cultivators, &c., abounded.

The reason why the reverse is the case with the ploughs is evident. Foreign cultivators will not be induced to adopt any startling innovation upon a practice which has always proved good to them, and if English makers would compete, and a very hard and close competition it is, with foreign makers of ploughs, they must conform to existing usages.

The well-formed rectangular, or crested furrow produced by an English plough, and seen almost universally on English farms, would be quite out of place in the great corn-growing plains of Wallachia, Hungary, or the South of Russia. The cultivators there prefer a broad and broken furrow, such as is made by the Ruchaldo, or Hungarian native share, for it suits their manner of cultivation, and more ground can be prepared in a given time than by the refined English ploughs.

We have said that the competition between home and foreign makers of these implements is a very severe one. Thus Sweden manufactures very large quantities of rough heavy ploughs, at a price lower than can be touched by English constructors, and though they are clumsy in their proportions, they suit at once the habits and the means of the Russian farmers, amongst whom they find a large and ready sale.

The leading German maker, Eckert, of Berlin, who combines work equal to that of our best makers with originality of design, and at least an equality in price, has no difficulty in holding his own in North Germany, and the Hungarian constructors, some of whom showed excellent material and workmanship, are absolutely running almost equal with the Swedish makers in price, but in general practice an equal lack of finish. Finally, the United States comes into the market with good and low-priced implements, although whether those prices can be maintained, or are only adopted to create a business, we cannot say.

England.

In reviewing the exhibits of the implements of tillage, we will commence with the ploughs, and we shall find it convenient to notice first those which were at the stand of Messrs. Ransomes, Sims, and Head, of Ipswich, for the simple reason that there were no other ploughs exhibited in that part of the Agricultural Hall leading to their stand. It is worth while noticing that

Messrs. Ransomes, and R. Hornsby and Sons, of Grantham, were the only two English exhibitors who so arranged their ploughs that they could be approached, inspected, and handled by the visitors, who, especially in the fall of the year, were largely composed of the agricultural classes from outlying districts, and who naturally gained confidence by being enabled to convince themselves somewhat practically of the various merits of the implements.

The first plough to be noticed in Messrs. Ransomes' exhibit was a small, cheap turnwrest plough, designed especially for light ploughing in easy ground. The sketch, Fig. 7, Plate 233, gives a clear idea of this implement. The frame is of timber, and the mould board, and share, the former of which is of cast, and the latter of chilled cast iron, are hinged, and can be swung round, so as to lie in a reverse direction. When in operation the share is held fast by a pin linked to the top of the beam, and hooked at the other end, into a hole in the top of the mould-board. There is no coulter to this plough, but the wing formed on the share takes its place. The depth of the furrow is regulated by the hinged quadrants upon which the leading wheel is mounted, which slides between clips, on each side of the front end of the beam, and can be locked at any point desired. Of course, the nearer the wheel is raised to the beam, the deeper the furrow is cut. The draught hook can also be shifted in position by placing the pin retaining it, in either of the holes in the plate shown in the end of the beam. We should mention in connexion with this plough, that the arrangement of the wheel and quadrants for regulating the depth of cut was found on some of the few ploughs in the United States' Agricultural Hall.

The second plough, we may mention, is one of a more advanced construction, but extremely simple in its details. It is adapted for light and medium soils, and will cut furrows from 4 in. to 9 in. deep, and from 9 in. to 12 in. wide. A team of two bullocks are required for this plough. The share is of cast steel, and the mould board is of a somewhat different form to that before noticed. The beam is of wood, and the front end rests on a carriage of simple construction. At the other end of the beam, near the point where the stilts are bolted to it, is a vertical rod, one end of which is attached to the body of the share, and the other passes through a hole in the beam, where it is held up by a nut, so that a means of adjustment is obtained when the point of the share wears. The fore carriage is mounted on two wheels of unequal sizes, the larger one of which runs in the furrow, and the smaller one on the untouched ground. The smaller wheel can be adjusted vertically, so as to regulate the depth of the furrow, as it is mounted on a square rod on which the wheel may be moved up and down, and secured in any desired position by set screws. The small sketch, Fig 8, gives an idea how this is effected, the detail being practically the same in all cases. The width of furrow can be regulated by shifting the square axle on which the large wheel is mounted more or less out of the centre of the beam, for as it runs against the vertical side made by a previous cut, it follows that the nearer this wheel approaches to the centre line of the share the narrower will be the furrow. The draught is taken by a chain linked to the fore carriage, and then brought back over the beam and attached to a hook on the upper side of it. There are three holes in the beam, into either of which the hook may be placed, and as the share wears the hook is advanced to compensate for it. We may here point out a detail of excellence in Messrs. Ransomes' ploughs, to be found in those of few, if of any other makers, and only employed by them in the better classes of implements, but seldom, if ever, for those made for exportation, in which such a refinement would be unappreciated. The axle has a collar turned upon it, and the nave, which is of the form shown in Fig. 9, is turned out perfectly true, the outer end being left closed. A plate is bolted to the inner face of the nave, over the collar, and interposed between them is a leather washer. In one side of the nave is formed an oil hole, closed by a screwed plug.

A special feature in this, and most of the ploughs built by Messrs. Ransomes and Co. for export trade, consists in the addition of a wrought-iron loop, bolted on the outside of the stilts near its junction with the beam. In throwing over the plough for the oxen to turn it round it falls upon the loop instead of the handle, thus saving the latter from injury.

The third plough, we may notice, is one manufactured by Messrs. Ransomes, from patterns partly supplied from Bohemia, and of which similar ones are to be seen in some of the Hungarian exhibits. Its principal feature consists in making up the body of the share and mould board with an angle iron instead of a plate framing, thereby producing a cheaper, and at the same time, a lighter implement. This plough has a fixed fore carriage, the axle of which slides through the square holes in a bracket underneath the frame; in order to obtain the variations in width of furrow, the wheels are both of them mounted on square vertical rods, so that each may be adjusted by sliding them up or down to suit the depth of furrow desired. The share of this plough differs from those before noticed, in being of the Ruchadlo pattern with a bluffer mould-board, and a share, forming a greater angle with the axis of the beam than in the English ploughs. The furrow produced by this share is flat and much broken up.

An implement made for the Russian market has a wrought-iron frame with fore carriage, resting loop on stilt handle, and an auxiliary wheel to help the plough round when it is thrown over on its side on turning the headlands. This plough is adapted for wide rather than deep ploughing, turning a furrow 18 in. wide, and from 6 in. to 8 in. deep. The wheels of the fore carriage are mounted on square rods, sliding in brackets bolted to the srames. The adjustment for draught or wear is made by means of a small quadrant in front of the frame, and the direction of draught is regulated by a vertical fixed slotted link, on one face of which is a coarse rack, between any of the spaces in which the shackle can be attached. The drawing, Fig. 10, shows the general arrangement of the plough, which is represented thrown over on its side for turning at the headland.

A three-furrow plough at this same stand possesses several specialties of construction. The breasts are of the Ruchadlo type, throwing up a very broken almost flat furrow, and turning over a total width of 30 in. The frame is carried on a pair of wheels 3 ft. diameter, which are mounted on a cranked shaft. In front is a smaller guiding and furrow wheel. A long lever with one end attached to the cranked shaft extends back as far as the handle of the implement, and by placing this lever in a horizontal position, where it can be maintained by a suitable bracket on the frame, the plough body is raised, and the implement can be drawn upon its wheels. On the other hand, when the lever is raised as high as it will go, the plough is thrown down to its maximum depth for forming a 7 in. furrow. Between these two extremes the depth can be regulated by means of a graduated quadrant bolted to the side of the frame, and in which holes are made at intervals, so that the lever may be locked in place by means of a pin. The front plate of the fore carriage in this plough is straight, and the line of draught is adjusted by means of a number of holes in the plate, into either of which the hook of the draw chain may be placed.

We may mention here that this plough obtained the first prize at the Government trials at Charkoff, in Russia, last October, in competition with a similar three-furrow plough, manufactured by Eberhardt, of Ulm, which was more expensive, and heavier in draught than its English rival.

We now come to the double English ploughs exhibited, but which formed rather objects of curiosity than of active interest amongst the agricultural visitors at the Exhibition. They are of a very advanced type, and may be employed either with two ordinary breasts and shares, or the forward breast can be removed and a subsoiler substituted. The shares and mould-boards of these ploughs are adapted for the most finished kind of English ploughing, either for the square work of the class, shown in Fig. 11, or the trapezoidal furrows, Fig. 12. For the former a share of the form shown in Fig. 13, is adopted, and for the latter, where the bottom is cut out in steps, as shown above, a share like Fig. 14, is employed, and to both the long sweeping mould-board which lays the ground over with so much regularity as it is turned up by the share. The frame is of wrought iron and is carried on three wheels, one large one forward, a smaller one on the other side of the frame, and an inclined or canted wheel, on the same side, and placed on the inner side of the

breast. This wheel is employed instead of a slade under the body to reduce friction in turning at the headlands. Both the forward wheels are mounted on square vertical rods sliding in brackets on the beam, to regulate the depth of furrow; the share can be tilted at the rear to compensate for wear, and the width of the furrow may be altered at will by increasing or diminishing the distance between the wrought-iron beams. These beams are connected together by rods, with screwed ends, and the space between them is regulated by setting up nuts on these rods. The beams also slide on the bar of the fore carriage. The handles of two levers are placed close to the stilts of this implement, the one linked to the upper end of the subsoiler, for throwing it in or out of work, and the other working on a quadrant provided with suitable stops for varying the depth of the furrow. The former of these is held down by a catch on the side of the stilt, the latter is retained by a spring in a detent cut in the quadrant. Fig. 15 shows the form and arrangement of this plough, as well as the mode of working the subsoiler, the blade of which is of the contour, given in Fig. 16. It is especially useful for deep cultivation, such as preparing the ground for roots, which require that the soil should be loosened to a considerable depth. The subsoiler enters the ground first, and to the right hand of the following share, which turns the furrow immediately over the subsoil, which has been already broken up by the subsoiler, and as the cattle drawing the plough always walk upon the untouched ground, the furrows are left entirely undisturbed. The ploughs of this class exhibited are suited to subsoil to a depth of from 10 in. to 12 in.

Fig. 17 shows the latest form of fore carriage exhibited by Messrs. Ransomes. It is that employed upon their so-called Newcastle prize ploughs, and it will be seen that a light iron saddle is placed over the beam, with square holes through its lower part, through which the axle carrying the blocks for the wheels passes, and is secured, means being at the same time provided for the axle to slide in the bracket. The blocks at the end of the axle are of the form shown in Fig. 8, and the vertical bar, which slides in the opening of the blocks, can be set at any point by means of the two set screws. In advance of the saddle bracket a joint is formed on the beam, and the extreme end carries a horizontal segment plate, pierced with a series of holes. The vertical draw link is provided at the back with a pair of jaws, between which the segment plate slides, and is secured in any desired position by means of a pin passing through holes in the jaws and segment plate.

A light double-furrow plough was also shown, with a wrought-iron frame, a friction canted wheel under the rear mould-board, and instead of a small wheel forward, a concave disc. This plough is shown in Fig. 18, thrown over for turning at the headland, and it will be seen at a glance that the disc is a detail of considerable merit, and one, from its simplicity, likely to find favour in foreign markets. For the rest there is no special novely about this implement. It is provided with a loop on the side of the beam, and both leading wheel and disc can be shifted vertically in the usual manner. A hinged segment shackle is pinned to the front bar, with teeth to regulate the angle of draught, and the beams may be made fixed or movable as desired, so as to work with a uniform or variable width of furrow. Fixed, 9 in. furrows from 3 in. to 8 in. deep can be made; and movable, furrows from 7 in. to 10½ in. wide.

An extremely good specialty, Fig. 19, shown by this firm is a double-furrow plough, adapted for Bohemia and Hungary, with a fore carriage of simple construction, and attached to the beam by a swivel, so that in turning the plough may be thrown over without disturbing the carriage. In this plough no arrangement exists for altering the width between the furrows, each share being attached to one of the two bars, which, together, form the double beam of the implement.

Two more English ploughs shown by Messrs. Ransome may be noticed, the one with an arm in front of the share to carry a revolving disc for cutting turf, or with a skim coulter for taking off weeds. The share takes either the turf or weeds thus cut, and in forming the furrow lays them at the bottom. The second plough has a deep mould board, cuts a wide furrow, and is provided with two of Robinson's grubbers, which produce somewhat the effect of subsoiling.

Finally, a Skelton's patent turnwrest plough was shown, a form much used, we believe, in the agricultural districts of the south-west of England. It is a most ingenious arrangement, with a fixed share, and two mould-boards, one on each side of the frame. By gearing actuated by a rod reaching near the stilts, either one of the mould boards may be thrown down against the share, the opposite one being raised by the same movement. An independent motion shifts the coulter to the right or left, according to the side which is being used.

Besides these implements we have described, Messrs. Ransomes, Sims, and Head, exhibited several other ploughs, which, as they possess no special detail of interest that has not already been touched upon, need not be referred to more particularly. The workmanship throughout was excellent, and the designs were good, while the suitability of the implements for the special requirements of the foreign trade have been generally well considered.

Messrs. J. and F. Howard, of Bedford, made a fine exhibit of ploughs, amongst which were a few especially adapted for the Hungarian and Bohemian markets, the principal part being, however, the more complete and expensive implements for home use. The plough corresponding to Messrs. Ransome's cheapest form, with fore carriage, is illustrated (see Plate 233, Fig. 20). It has a wrought-iron frame, the beam consisting of two parallel bars between which the body of the plough is fastened by a bolt, as shown. One stilt is attached to the beam, the other to the outside of the breast, after the American type. The share, like nearly all of Messrs. Howard's make, is of chilled cast iron, and the breast fits to the underside of the beam with a saddle. The fore carriage is of very simple construction, with a segment plate on the small frame carrying the brackets of the wheel bars. Within this segment the end of the beam turns, and on the upper side is a recess cut, in which fits a detent connected with the end of the bent bracket, attached to the top of the beam, forward of the coulter; a light rod connects this detent with a hand lever, fixed to the bracing between the stilts, so that by drawing on this lever the detent is raised, and the plough is free to be thrown over. The draught, as will be seen, is taken from the underside of the beam a little in advance of the coulter.

One of the completest ploughs at this exhibit was the double-furrow implement shown in Fig. 21. The mode of attaching the body will be seen in the illustration, and the method of mounting the anti-friction wheel on a spur of the body behind the following breast. The principal feature of the implement is, however, the introduction of the turning wheel, used to avoid the plough being thrown over at the headlands. The wheel is mounted on the lower extremity of a cranked lever, to the upper end of which is attached a rod leading back to the stilts. A small finger projects from the underside of this rod near the handle, and catches in a loop provided, so that when the lever is pulled back, and the wheel raised, the finger engages in the loop. When, however, it is desired to turn the plough, the small wheel is lowered, and the tine or bar, shown fastened to the bracket carrying the wheel, enters the ground, and forces the wheel to its proper bearing. The form of the wheel is such as to allow it to turn laterally. In these ploughs a steering lever is also provided, going from the rear to the fore carriage. The whole of the frame is of wrought iron, and the beam is made to expand so as to alter the distance between the shares.

Messrs. Howard showed a neatly designed potatoe plough, with the ordinary arrangement of finger breasts, mounted on a long slade, a ridging share and breasts can be substituted for these, and the implement used for earthing up potatoes; the breasts are arranged to expand, by means of a pair of screws, by which they are attached to the body. Finally, in Fig 22 is shown a plough which fairly represents Messrs. Howard's pattern of beam, &c. The implement, however, is fitted with a peculiar skeleton breast, the fingers of which fall inward from the top; it has two grubbers or subsoilers behind it, attached by brackets, as indicated. This plough is employed for light work, and especially after harvest when it is desired to break up the soil, the fingers on the breast serving this purpose admirably, as owing to their peculiar form the earth falls through the spaces in the breast, and is thoroughly divided.

We may here remark that we find very similar details and specialities of construction common to four of the leading English makers of ploughs, who

by a mutual arrangement are licensed to employ the various patents possessed by these same firms. With such a very large and continually growing number of patents upon plough details, constant disputes must have resulted if this arrangement had not been carried out by the different makers.

Turning now to the exhibit of Messrs. R. Hornsby and Sons, of Grantham, we find the first of the ploughs shown by them is a very comprehensive implement, quite a general joiner, in an agricultural sense. Fig 23 shows the plough arranged for ridging with expanding breasts opening from 12 to 24 inches. The frame is of good design and construction, differing, it will be seen, in many points from either the Howard or Ransome type. It runs simply upon one wheel sliding in a bracket bolted to the frame. When required for ordinary work the ridging share and body are removed, and an ordinary one substituted. One feature in this share is to be noted. It terminates in a bar passing under the breast, and attached to the body in such a way that its position and angle can be adjusted so that as the share wears away it may be set up again.

As a potatoe raiser this plough has its next function, a long slade with the ordinary potatoe share, and leading and following finger breasts being attached. Finally, a hoe frame with two tines may be substituted for the plough body. A marking bar with pointed ends, and sliding on an arm standing out from the frame will be noticed in the engraving. This is supposed to be useful for regulating the furrows. In giving all credit for this ingeniously combined implement, we cannot help thinking that the makers have attempted too much, and certainly it has too large a scope for the desires of the Hungarian or Bohemian purchasers of ploughs.

Messrs. Hornsby's cheap Hungarian plough is a good and serviceable implement. It has a cast-iron body and breast, and chilled cast-iron share; the fore carriage has wheels of different sizes, arranged to slide in the usual way, and the plough is thrown over by a beam turning in a loop or stirrup on the top of the fore carriage. We may mention here, that these makers always bush their wheels, so that when the bearings are worn, new bushes may be put in, and the wheels retained.

The single English plough of these makers is also a good implement, though quite unsuited for the Austrian or Hungarian market. The body is curved and light, supporting the share well, and the breast is of the ordinary long sweeping English type; a canted antifriction wheel is placed behind, and altogether the implement, while meriting commendation, possesses no special feature to be noticed.

We must, however, call attention to the prize double-furrow plough of Messrs. Hornsby, which was exhibited at Vienna, uselessly, we should imagine, so far as all purposes of trade are concerned. It is a double-framed instrument with one of the bodies attached to the main beam, and the other adjustable upon a diagonal bar, that forms a part of the frame. By this means, the width of furrow can be varied.

The forward end of the beam rests on a single wheel, the height of which can be regulated, and a very simple and efficient steerage arrangement is introduced, which is actuated from between the stilts by a long lever. For turning, a special and ingenious arrangement is adopted. On an independent transverse frame, turning on suitable bearings in the main frame, are, on one side a wheel and on the other an iron slade, the underside of the wheel being at a considerably higher level than the bottom of the slade. By means of this wheel the depth of furrow can be absolutely regulated, for as its rise and fall are under the control of a lever going back between the stilts, it follows that, by elevating or depressing this lever, the depth to which the shares enter the ground is regulated, as the wheel, which has a broad tire, runs on the untouched ground. This adjustment is managed as follows: a long set screw, passes through a bracket in the side of the lever, in such a position that the end of it comes in contact with the top of one of the frame bars; now as this screw is more or less advanced through the bracket, the greater or less is the throw over of the lever, and the height of the wheel above the ground. As there is a canted antifriction wheel under the following breast, the implement when at work runs upon three wheels, and in turning at the headland, upon two wheels

and the slade. Altogether this is a very complete plough, and one that has brought the makers much credit.

Two more English makers may be mentioned as having exhibited ploughs, namely, Messrs. E. Page and Co., of Bedford, and Messrs. G. W. Murray and Co., of Banff. The former of the two had quite a number of ploughs, but none of them which call for notice; the latter exhibited only one implement, a double furrow plough, which has an arrangement for raising when it is desired to turn, and so reduce the work of the ploughman; the leading wheel is also made with a tyre of a peculiar form.

It will thus be seen that only three English makers of repute had any extensive and striking exhibits at Vienna, Messrs. Ransome, Howard, and Hornsby. It is to be regretted that, amongst these eminent manufacturers, some specialities suited to the requirements of the market in the south of Europe were not shown. Messrs. Howard, for example, make a large number of Swedish-pattern ploughs at a very low price, and had similar instruments to these been exhibited, more beneficial results would have probably followed than could be expected from the exhibition of the highly-finished, and perfect, but more or less costly ploughs, that formed the largest portion of the collections.

United States of America.

Very few ploughs were exhibited in the Agricultural Hall belonging to the United States, nor were any of them specially remarkable for excellence of design or detail. Messrs. Collins and Co., of Hartford, Massachusetts, showed a large two-horse plough, their so-called "Eclipse," which was a remarkably fine piece of work, but fit only for exhibition. A similar plough in another part of the hall was a practical implement, but of decidedly inferior workmanship. The principal feature of the plough, apart from the frame and seat for the driver (an arrangement entirely unsuited for continental farmers), is the introduction of two levers operated from the seat. The first and right hand of these places the shares in position; the second, which is the most used and is very inconveniently situated for the driver, is employed to lift the shares out of the ground. Attached to the lever is a saddle-shaped clamp, which clasps the rim of the wheel, and when it is desired to lift the plough, this saddle is pressed upon the tyre, so that the work of raising is done by the team. The depth of furrow is set upon a quadrant with a sliding stop, against which the lever is moved up. The two wheels are of the same size, and are mounted on cranked axles. The same maker showed a couple of neatly made hand ploughs, with steel mould-boards, shares, and land sides, the shares being of the form shown in Fig. 24, with points cast solid for a depth of 3 in. The simplest form is without any forward or gauge wheel, but in the sole of the standard carrying the share, which is fastened to the beam, there are two slots, by means of which an adjustment can be made for varying the depth of the furrows. In another form a wheel, mounted exactly as in the Ransome plough first noticed, is employed, the quadrant sliding in a similar manner on the beam. The link for the draught is held to the beam by means of a pin, the upper end of which forms the spanner for tightening or loosening the bolts.

A plough made by the Peekskill Plough Works, New York, is shown in Fig. 25. It is entirely of cast iron except the share pins and stilts, and a merit is claimed by the inventors for the use of the peculiar curved beam, it being urged that the draught is brought into a proper line, with a shorter beam, than is possible if the latter is straight. It will be noticed that the point of the share is prolonged, a good feature, as it allows for wear. The beam is cast with three ribs on it, and at the rear it is extended out so as to form the body to which the share is bolted.

In the implements provided with a front or skimming share, the standard of the latter is made with a rack upon its inner face, and is raised up or down by means of a pin in the side of the beam.

Messrs. Furst and Bradley, of Chicago, showed a good and simple hand plough, with a rolled iron beam of I section; the point of the share is very long to allow for wear, as in the one previously noticed. Besides these there

were a few other makers, who, however, exhibited nothing worthy of mention, and it is fair to assume that the United States failed altogether in being represented in this branch of industry.

SWEDEN.

Returning to the Western Agricultural Hall, a large number of Swedish ploughs were found, contributed by several different makers, all of them characterised by extreme cheapness, most of them by roughness of work, and a few by originality of detail.

From the machine works of Ofverum in Sweden were a large number of these implements, some sold at the remarkable price of 18*s*. They were all very practical in design, but extremely rough in workmanship; several coarse copies of English ploughs were to be found, and some had the share, mould-board, and body all cast in one piece. Several American patterns of shares and breasts were here, but the majority were modified from English forms. Amongst the specialities was a five-furrow plough, the shares of which are all small and very square. The implement has a wrought-iron frame, and the bars carrying the shares are jointed to the beam. These bars are kept always parallel to each other by means of distance links, and the spaces between them can be regulated by a motion similar to that of a parallel ruler. A quadrant on the frame serves as a means of locking the series of shares at any desired angle with reference to the beam. There was also a heavy three-furrow plough with a wooden frame. The centre share is bolted to the beam, from which, in front and behind, project two pieces of wood at right angles to it. Slots are made in these pieces, and the first and last share is secured to them, so that a traverse may be given to them in adjusting the width of the furrow, the middle share always remaining fixed. The pole of this plough is attached to the beam by a loop bolted to the side of the latter. A large subsoil plough of very heavy draught, and with a long projecting breast to the share, rolled in one piece with the slade, completes the list of specialities contributed by this firm.

We may group together three Swedish manufacturers,—Westlanderholm, the Forsviko Engineering Works, Nafveqvarn, and the Gottenburg Machine Works. These firms showed collectively a great number of ploughs of better finish than those of the makers just noticed, while the prices were extremely low, really excellent implements being sold for 30*s*. in Vienna, and of course at a lower price at the works in Sweden.

Mr. S. Wagner, of Hägendorf, showed an implement more ingenious than useful. It is a turnwrest plough, with the share, mould-board, and body doubled, so that it can be turned in a horizontal plane, and present at each half revolution a working face; the turning is effected by means of a lever, the handle of which comes back between the stilts, and has a slot formed in it. This slot falls over a pin on a nut placed on a screw shaft, which passes horizontally between the stilts, so that when the lever falls down the share is thoroughly locked, but the pitch can be altered by turning the screw. The coulter is adjustable, the required motion being obtained simply by pressing a small lever to which the coulter is attached to the right or left of a tapering plate fixed on the beam, the angle on the plate throwing the coulter over in either direction.

Mr. G. Vogt, of Utzingen, had also a balanced turnwrest plough, with two mould-boards, one on either side something like the Skelton implement before noticed. The mould-board and share, however, are locked together by means of a long pin going down into the slade plate. In front of this plough is a fore carriage, the arrangement of which cannot be understood without difficulty, and was altogether as complicated a piece of mechanism as could be seen in connexion with agricultural machinery.

Mr. S. Staufiger, of Wiedlisbach, had a somewhat similar turnwrest plough, the design of which is, however, much happier. The breast and share are locked as in the Vogt implement, and the coulter is adjusted by being slightly cranked, and moved by a short handle above the beam. The arrangement for adjusting the depth, &c., of the share is still complicated, and

the parts are very light, too light to withstand the work that must be thrown upon them in practice.

Finally may be mentioned another series from the Akers St. Bruck, in which no originality of design could be found, only strong workmanship and cheapness. The breast and body of the plough are cast in one piece, and there is a wing on the share to save the addition of a coulter, similar to that of the Collins American plough before mentioned. Of course these implements presented no finish, but there appears little room for doubt that they are highly serviceable and durable.

Altogether, the Swedish collection of ploughs was a very remarkable one, and explained fully why those makers enjoy so large a share of the North Russian trade. Hitherto we believe, however, that they are not in favour in Austria and Hungary, and, despite their cheapness, but a small business at Vienna was done with them. Probably an inspection of them has been serviceable to English makers, who have their makers as competitors.

Germany.

Passing now into the Agricultural Hall at the eastern end of the Exhibition, and devoted to the exhibits of Germany, Austria, Hungary, and Russia, there were placed immediately at the entrance the most complete collection of ploughs to be met with throughout the Exhibition, These were contributed by the Eckert Manufacturing Company of Berlin, and were remarkable for the excellence of their workmanship, the originality of their design, and their moderate cost.

The first to be noticed is an implement intended for beetroot cultivation, and is shown in Fig. 26. It has a small share in front that throws over about 4 in. of the surface, and is followed by the large share and breast behind, which penetrates to a depth of 14 in. The front end of the beam rests on a fore carriage running on two wheels. Figs. 26 and 27 will help to explain the arrangement of this carriage, which is extremely good. The axle *a* is cranked at the end upon which the large wheel is mounted. Upon the axle is a long cast-iron sleeve *b*, and the bent draw bar *c* embraces the axle at one end outside the sleeve, and at the other end it passes around it within an enlargement cast upon the sleeve, as shown. A pin *d* goes through a hole in the axle, and keeps all in place. Now, if it be desired to alter the depth of the furrow, by adjusting the position of the large wheel, the pin *d* is removed, and the sleeve is slipped along the axle for a short distance. At the end of the sleeve next the crank, is a toothed quadrant *e*, into one of the spaces of which a pin *f*, fixed to the crank, enters. It is clear, therefore, that when the sleeve is slipped back into its normal position, but turned round more or less, the pin *f* will enter a space varying according to the extent of the movement, and the position of the large wheel will be affected to a corresponding degree. The pin *d* is then returned to its place, and the fore carriage is fixed. Upon the top of the sleeve is cast a flat table *g*, with a number of grooves in it, at right angles to the axis of the axle. Within this table there is a ⊥-shaped groove, in which the end of the upright bar of the carriage, *h*, suitably formed to fit the groove, slides to and fro. In the lower part of the bar is a slot, and a key passed through this, and locking at the same time in one of the grooves, secures the bar in position, so that by shifting the position of the bar the centre line of the plough, with regard to the wheels of the carriage, can be altered at will. The draught is taken from the frame, as shown, by means of a strong chain attached to it, and the latter, so as to take the strain off, and retain the carriage in position. Near the top of the bar *h* is a collar embracing it, as shown, between two bosses, and pinned to a cast-iron plate behind, which forms the socket for a swivel motion in throwing the plough over. In the upper part of the plate is placed a pin *j* with an eye at one end, and a swinging cross pin *i* is on the swivel. This, when one projection of the cross pin is in the eye of the swivel, serves as an efficient locking apparatus, and when it is thrown out, the plough may be thrown over with the greatest ease.

The beams of nearly all the Eckert ploughs are of wrought-iron I-section, and the stilts are also of iron, turned round and fastened to the

web of the beam, as shown on Fig. 26. In the same figure it will be seen that a loop is fastened to one of the stilts, to receive the weight of the plough when it is thrown over.

Another point to be especially noticed is the adoption of a movable chisel point to the shares, as indicated at *a* in Fig. 27. The bar, of which the chisel point seen forms the end, is of considerable length, and projects inside the body of the plough: it is made alike at both ends, so that it can be reserved when one end has been worn down. There is a bracket fastened to the inner side of the body, through which the bar passes, and, its edges being serrated, it can be held fast by a set screw in any desired position.

Fig. 28 shows a simple form of plough which was represented by several examples at the same stand. It will be seen to possess the leading characteristics already noticed, namely, the I-beam, fore carriage, iron stilts, and chisel-pointed share. The beam is bent over at the back, and nearly approaches the ground, in order that the body may be rivetted to it. At the end of the body there is a T-iron slade fastened.

The same form of beam is preserved in the double and three-furrow ploughs. Fig. 29 is a good example of the latter. The main beam, as will be seen, is in the centre, and the frames for the forward and rear shares are bolted to it, a sufficient curve being given to allow for the width of furrow desired. Of course these widths are not variable, and the three beams are rigidly, but somewhat too lightly, braced together. The stilts are of iron, bolted to the lower part of the beam just above the mould-boards. The draught is taken through a chain or bar attached to the centre beam.

Finally is illustrated a ridging plough with adjustable wings, Figs. 30 and 31 having the same form of beam, but only a single gauge wheel in front, the vertical bar of which is free to turn in a socket bolted to the beam, and around which passes the draught shackle. The plan, Fig. 31, shows the mode in which the angle of the wings can be adjusted, an angled plate under the stilts being provided with a number of holes for that purpose.

In addition to the actual ploughs, the Eckert Company exhibited a number of models very finely executed, but showing nothing that could not be seen better in the implements themselves.

Near to this exhibit was a plough contributed by G. A. Markwart, of Zechin. The share and breast of this instrument were painted to represent granite. The rest of the machine corresponded.

Heinrich Frome, of Holzmunde, showed an ingenious arrangement, but one which has probably but little practical value. It is a wrought-iron framed implement with a skim share in front, and a fore carriage, the position of which relative to the plough may be regulated by a screw and lever from the back, while between the stilts is a second lever connected with three narrow and sharp blades that can be thrown by the lever through the mould board from the face of which they project several inches. The apparent object of this is to pulverise the soil as it rises up the mould-board. The shares are adjustable by means of a screw and small lever connected to the beam. Whether the good effect obtained would in practice repay the extra trouble and expense of construction is, we think, very doubtful.

Mr. R. Sack, of Plagwitz, near Leipzic, exhibited two ploughs, one with a horizontal wheel below the share, instead of a slade, to reduce friction in working, the other one of formidable size called the Rajol plough, for very deep work, and adapted to cut furrows to a depth of 24 inches. Of course the whole of the framing of this plough is very massive, and a peculiar locking arrangement is adopted. A lever extends to the back of the plough between the stilts, having its fulcrum in a point above the beam, and near its forward end. Beyond the fulcrum the lever is bent over, terminating in a projecting finger, which when the lever is in its normal position, enters a hole made in the post, and locks the carriage; on raising the lever, however, the finger clears the post, and the plough is free to swing. A screw adjustment is provided for regulating the depth of furrow.

Passing by now a few other makers who sent ploughs, about which no remarks are really called for, we come to the last stand in the hall, that of Messrs. Eberhardt Brothers, of Ulm, who occupied a position exactly corresponding to that of Eckert, on the other side of the doorway. This firm had a very large collection of ploughs so arranged, however, that they were almost inaccessible. A glance showed that there was little of novelty in their construction; and though the work is very fair, it cannot be compared to that of Eckert. As a rule their implements are of simple construction, and are adaptations from several English makers. They merit, therefore, no further notice.

Bohemia.

The capital of Bohemia is the centre of a vast agricultural district, and naturally the representatives of most of our home manufacturers of agricultural machinery are found there, while at the same time similar native industries of importance have been developed. We may first mention Mr. Bernhard Eichmann, who exhibited at Vienna a number of ploughs, of which we may notice briefly those which showed a speciality in design. Amongst others is a standard ruchadlo plough, which is represented in Fig. 32. It is built of wood, and the share is of the peculiar form shown. It will be seen that a spindle projects above the top of the share, terminating with a square end, over which a key is placed, and by which the angle of the share can be altered, and locked by throwing the lever into the notches formed in the strap over the beam. Fig. 33 has a share of the same type, but it is altogether a lighter, indeed too light, an implement. The handles are of wood, but the stilts themselves are of iron, curved, as shown, and bolted to the rear end of the beam, then extending downward, are attached to the inner side of the horizontal bar forming the body. A couple of curved rods lightly tie the ends of the stilts to the bars. According to Mr. Eichmann, in the true ruchadlo blade the vertical height from the point of the share to the top of the mould-board should measure the same as the width across the top of the mould-board, while a diagonal line drawn across the blade from the corner of the mould-board to the point of the share should form the chord to an arc of a circle 19 inches radius, the curve of the share. In this collection we need only notice further a plough of a similar type, but with the share and mould-board modified to somewhat of an English form, and a ruchadlo implement with two of Robinson's grubbers behind it.

Hungary.

Passing on to the Hungarian exhibits, the first for notice is that of Gubietz, of Pesth. There was nothing novel in design about these ploughs, excepting that a bar projects out from the front bar of the carriage, and is then bent round parallel to it, the parallel part having a number of holes corresponding to those in the front bar of the carriage. The pole thus receives a double attachment, which appears a somewhat superfluous detail. The shares and mould-boards in these ploughs are of wrought iron, the bodies of cast iron, they have wooden beams and stilts, and are provided with a coulter; the set of the share is varied by a screw which alters the level of the beam. The whole of these ploughs show very good work, and the price is low; such a plough as has just been described being sold for 2*l*.

Edward Kühne, of Wieselburg, showed good material well worked up in his ploughs, which were, moreover, very cheap. Many of his exhibits, too, had no indication of having been imitated from foreign implements. He had a six-share cultivator of the form shown in Fig. 34 in which the shares are set in a beam turning on a centre beneath the true beam of the implement. There are two segments around which the lower beam turns, and upon which they can be locked at any desired point. At the rear of the beam is a sort of tail-piece acting as a slade.

Fig 35 shows a plough of which the leading feature is the same in principle with that of the "Cosmos" plough, made and exhibited by Ransomes, Sims, and Head, although, of course, the mode of carrying it out varies considerably. The body, instead of being formed of an angle-iron frame, has a vertical post

of wood, as shown in the figure, and a horizontal slade frame of cast iron. In all other respects the two ploughs differ widely. In that illustrated there is no fore carriage, but a vertical bar with a slade at the bottom ; the bar can be raised or lowered by means of the rack cast on its edge. Such a plough costs about 2*l.* 1*s.*, and some 3*l.* 12*s.*, with the fore carriage added. An arrangement for varying the line of draught is shown in Fig 36. It consists simply in a broad link swivelling from the end of the beam, upon which is placed a segmental rack. A pin, attached to the beam by a chain, is passed through the link, and locks it at any desired angle. The draught is taken through a chain held up by a vertical bar sliding on the link before spoken of.

M. Vidats, of Pesth, is one of the largest of the principal manufacturers of agricultural implements in Hungary, and he has been naturally regarded as a formidable rival by English firms engaged in the same business. Moreover, the work in his ploughs is good, though without finish, and those exhibited were fair types of the implements he sells by the thousand every year. M. Vidats does not hesitate to copy from English models when he sees an advantage in so doing ; but he knows, moreover, how to preserve those details and characteristics appreciated by the agricultural districts where he finds his customers. We may note, in addition to the large number of ordinary implements he showed at the Exhibition, a few of special design. One was a large plough, provided with a seat for the driver, the second of the only two examples that were met with, the first being the "Eclipse" plough in the American Agricultural Hall, and already referred to. To the Vidats implement we should decidedly give the preference, both for design and workmanship. The frame is of wood, and the seat is mounted on a spring. American fashion. On each side of the seat, and above the frame, are a pair of small wheels with a chain around them. These are mounted on a shaft, at the end of which are levers to turn the wheels and lift up the plough, the backward motion being stopped by a pawl and ratchet. The wheels are on a cranked axle, and a lever, working in a quadrant, under the control of the driver, regulates the work. Probably this plough is a copy of some American implement which found its way into Hungary. M. Vidats showed conspicuously a fine plough for cutting 16 in. furrows, but which possesses no special feature for notice, except perhaps the arrangement for locking and unlocking the beam. In contact with the end of the beam, and on the fore carriage, is a disc, having a recess cut in it. In this recess fits a detent on the end of a lever attached to the beam, and kept always locked in the disc by a spiral spring, which constantly presses on the underside of the lever. By compressing this spring the lever is thrown up, and the plough unlocked, ready to be thrown over. The utility of this arrangement is doubtful, as the man in charge must leave the stilts to release the gear.

The remaining Hungarian makers and exhibitors of ploughs to be noticed are Messrs. Strobl and Baris, of Buda-Pesth, Messrs. Zanais and Stoye, of Oldenburg, and A. Scholz. None of these exhibitors however demand any special notice, with the exception, perhaps, of the one last named, who had a very large collection of ploughs, many of them adapted from American patterns, and none conspicuous for good design or workmanship.

Russia.

In the Russian section there were but very few ploughs exhibited, but sufficient to show that a different type exists, which is interesting for the sake of comparison with those already noticed. Ladislaus Mencil, of Bialazerkoff, showed one plough of extremely heavy construction, and very good workmanship, apparently a primitive form, considerably perfected.

The beam, fore carriage, and stilts are of wood, as is also the mould-board, a large heavy concern, with a very steep slope, and comparatively little sweep at the top. The share is of cast iron, made in one piece with the body. It is formed with a vertical standard terminating on top with a sole plate, butting against the underside of the beam, and secured thereto by a strap passing over the beam. To the rear comes the hind part of the body passing through the beam, and bolted to it.

The forward end of the pole rests on a bar belonging to the fore carriage. This bar is carried between a pair of double vertical standards bolted to the square wooden axle of the carriage. In the standards holes are made, as well as in the bar carrying the pole. By these holes the vertical and horizontal position of the bar can be regulated, the latter being fastened to the standards by pins. On the bar is forged a short horn, against which the pole is always pressed by the draught, so that it is clear the direction can be changed at will by sliding the bar to and fro, or up and down. Projecting from the axle of the carriage is a short front pole, with an adjustable quadrant between the pole and the axle, which permits of an additional adjustment. Finally, in the end of the plough pole, there is an iron loop, through which a chain is passed, and is brought down over the front pole of the carriage.

Roman Cichowski is the euphonious name of a gentleman from Linow, who appeared—judging from his announcements—to consider that he has a special mission to reform the whole system of plough design and construction.

What were the great advantages he gained did not appear from his exhibits. He showed a number of very poorly-made implements, of which the most important were two and three furrow ploughs. These are mounted on a wide rectangular wooden frame, the outside bars of which are prolonged behind to form the stilts. A centre beam runs down the centre of this frame, and projects beyond the forward cross bar. It supports at the end the brackets for a small wheel, which can be adjusted vertically. On the left-hand side of the rectangular frame is a second wheel. The shares are carried on a beam extending diagonally from corner to corner of the rectangular frame, and the draught is taken through a chain attached to the back cross beam of the latter.

Finally, we may mention the firm of Messrs. Lilpop, Rau, & Co., of Warsaw, who showed a collection of extremely well-made ploughs, which possessed however no special novelty of design.

Austria.

Mr. H. Praski, of Pottschach, Austria, had two ploughs, one of them singular in being entirely of wood, except a very light shovel-shaped share, the axis of which corresponds with that of the beam, and which is entirely without adjustment of any kind, and the second a somewhat better finished implement, of a similar type, with a screw arrangement for altering the set of the shares.

We may group together Anton Burg and Son, of Vienna, and Hopherr, of Vienna, both of which firms were conspicuous in this section of the hall for the number and excellence of the ploughs they exhibited, at the same time there was no novelty to be seen in their implements, the prototypes of most of which could be met with at the English stands.

Fig 37 shows the only plough exhibited by Messrs. Clayton and Shuttleworth, of Vienna, and made by them for the Hungarian market. It has no very special feature, has wooden beam and stilts, light fore carriage, and adjustable wheel, steel share, wrought-iron mould-board, and cast body. The form of mould-board resembles the Vidats breast, and the whole implement is made as Clayton and Shuttleworth make all articles they manufacture.

Outside this Agricultural Hall was a heterogeneous mass of ploughs and other implements, of which it is impossible and unnecessary to attempt a classification. Most of them appeared to have been thrown down at random, and remained in the open air during the whole period of the exhibition. Others were under cover, and were arranged properly by their different exhibitors.

Here there were two ploughs of the "Cosmos" pattern, already described, as forming one of the specialities at the stand of Messrs. Ransomes, Sims, and Head. These ploughs, which were rough in workmanship, were apparently made by the originator of the detail, for whom Messrs. Ransomes have taken up the manufacture in England. By the side of them was a very singular plough, patented by Mr. J. Kretschmer, of Weisskirchen, near Reichenburg. The share proper of this plough is inclined at an angle corresponding to that of the furrow. Behind it comes the mould-board, almost rectangular, and with a slight screw given to it. Finally, there is a horizontal second share or

subsoiler, extending from the rear of the mould-board to the back of the share, and at right angles to the latter. This share has at the forward end a wing or horn projecting from its upper face, and set at an angle corresponding to the furrow.

Close by there were several crude turnwrest ploughs, with the mould-boards attached rigidly to the beam, which is turned round to right or left, as may be desired.

Messrs. Fischer Brothers, of Wiener-Neustadt, exhibited one gigantic beet-root plough, with a steel share, wrought-iron mould board, and beam and fore carriage of timber. The draught upon this plough must be tremendous, and it was by far the largest implement of its class in the Exhibition. One somewhat similar, and also for deep cultivation, was shown by Mr. F. Behrendt, of Wanzleben, near Magdeburg.

Besides the ploughs collected in the departments devoted to commercial exhibits, there was another and very fine collection in the building of the Austrian Chamber of Agriculture. These formed an historical series, and were objects of great interest and curiosity. We have, however, done as much justice to this section of agricultural machinery as our space permits, and a notice of the series just spoken of would have little real value.

We trust we have said enough to prove the assertion made at the commencement of this review on implements of tillage, that the competition between English and foreign makers for the plough trade of southern Europe is very severe, and is one in which the difficulties must increase year by year. Prejudice in favour of native manufacture, price, and an ignorance of the exact requirements or customs of this or that province, are the great obstacles in the way of a continuance and increase of the plough trade of English makers. To increase that trade, even to maintain what is left them, requires a careful study of the dangers mentioned above. Some of the English exhibitors, as we have seen, sent out ploughs to the Vienna Exhibition exactly of the type made by them for home use, ignorant that their stands might well have been empty for any practical use their exhibits could be to them.

First to ascertain exactly the class of implement wanted, and, second, to produce it at the lowest possible price, and made in such a way that it can be easily repaired with the utmost facility, are the rules which must govern more than ever the manufacturer at home, who wishes to enter, or to hold his own, in the foreign plough trade.

Implements of Tillage.—Miscellaneous.

We now come to a consideration of a number of miscellaneous implements of tillage, which it will be convenient to take collectively, although their functions are not dependent or consequent upon each other. These are the horse rollers, crushers, harrows, and hoes, of which not a large number were exhibited at Vienna, and nearly all of which were either by English makers, or copies from English patterns. With these implements it is not the same as with the ploughs, most of them are of comparatively modern date, and of English origin. It was, therefore, only natural to find repetitions on every side amongst the German, Austrian, and Hungarian exhibitors.

England.

We commence with these implements, as with the ploughs, at the stand of Messrs. Ransome, Sims, and Head, there being none in the first part of the Western Agricultural Hall. This firm only exhibited one harrow of their regular pattern, shown in Figs. 38 and 39. Its peculiarity lies in the fact that it is made flexible, so that the tines adapt themselves to any irregularities of the ground. The harrow consists of three parts, the transverse bar, the zig-zag bar bent over at the end to form the tine, and the cast-iron clip, which keeps the parts together. The tines are steel-pointed, and any one can be taken out with the utmost ease in case of breakage.

Messrs. J. and F. Howard, of Bedford, had a very small show of tillage implements, except ploughs. They showed only a number of harrows of different

kinds and sizes, some of which are made partly flexible, by jointing the rigid bars at intervals with a loop and quadrant, in the latter of which there are three or four holes, through which, as well as through a hole in the loop a pin passes, and makes the joint. The front teeth of the larger of these harrows are straight and pointed, the following rows have broad, curved, and sharp tines.

Fig. 40 shows another form of harrow exhibited by the same firm. The tines here form part of a series of small three-armed frames linked together by rings.

All of Messrs. Howard's harrows have been freely copied by the foreign makers.

Messrs. E. Page and Co., of Victoria Iron works, Bedford, showed one or two rigid harrows, with the peculiar attachment of tines, shown in Fig. 41. From this sketch it will be seen that at each intersection of the iron frame bars, there is introduced a cast-iron block, notched on to the lower bar, and with a lug extending, so as to form a distance piece between the bars of the frame. Through this lug, as well as through the bars, a bolt passes, securing the whole together. The tine enters the square opening in the bracket, and is held fast by a key. It will be seen that this arrangement is a very simple one, and it has the advantage of being easily and quickly repaired. Of a different class is the rigid harrow by the late Mr. Weetman, of Ipswich, in which the tines are made with eyes at the upper end, through which one series of rods pass, and the other slip over, in such a manner that if one tine has to be replaced, the whole group must be taken to pieces. On the other hand, it has not the disadvantage under which Page's labours, that there are a number of independent brackets, which are liable to break, and which may be replaced with difficulty.

We now come to the stand of Messrs. Coleman and Morton, of Chelmsford, and may first notice an implement shown in Fig. 42, and which has no proper classification. It is a potato digger, and certainly has the merit of ingenuity, but is not said to work well—at all events it is a comparatively new implement in this country. It consists of a wrought-iron frame, something like that of a plough, and has, in fact, attached to it a share, with broad double mould-boards. Behind them are two other mould-boards formed with curves, the reverse way of those in front. Running on bearings attached to the frame is a large wheel, having around its periphery a number of fingers arranged as shown in the drawing. There are stilts to the implement, and in front, instead of a fore carriage, two wheels moving vertically through the slides in the brackets bolted to the frame. The angles of the rear mould-boards can be adjusted, as shown in the engraving, by means of the nuts which hold them to the slotted ends of the brackets depending from the frame.

The action of the implement is as follows: The share is run through the row of potatoes, and throws up roots and earth together, projecting them against the rear mould-boards, which throw them back again between the fingers on the large wheel. This, in revolving, clears the potatoes from the earth, and drops them in a continuous row behind the machine as the latter advances.

The speciality of Messrs. Coleman and Morton's exhibits was, however, their cultivator (employed to clear out weeds, instead of a second ploughing in spring, &c.), for which they are well known, and which several foreign makers exhibiting did them the honour to copy. This implement is shown in Fig. 43, and is the largest size shown by the makers, who had also two other implements, one with five, the other with seven tines.

It has a wrought-iron frame, and runs on three wheels, the trailing pair being mounted on vertical bars, sliding in brackets outside the frames, and these wheels can be raised or lowered by means of two levers worked in a segment plate, as shown. The main axle of the implement is carried in bearings on each side of the frame; on this axle are a number of cranks with levers pinned to them, the opposite ends of which engage in the looped heads of the tine rods. In the centre of the implement is a quadrant, and working against it is a main lever attached to the axle. By throwing over this lever the tines are all raised simultaneously, and any desired position is maintained

by locking the lever in place with a pin passed through the holes in the quadrant. It is to be noticed that the tines do not form a part of the rods, but can be removed, and others of any desired shape substituted. The implement is in all respects well made. Mr. Weetman, of Ipswich, showed a smaller cultivator, one with five tines, and Messrs. Richmond and Chandler, of Manchester, a chain harrow attached to a small plough for burying weeds, &c.

The horse hoe exhibited by Messrs. R. Hornsby and Sons, of Grantham, was perhaps the best implement of its kind to be found in the Exhibition, although it embodies no special novelty of detail claimed by the makers, it being on the Priest and Woolnough model. It is a ten-tined implement, carried on a pair of wheels mounted on a cranked shaft, in the centre of which is a toothed wheel gearing into a worm. This worm is actuated by a short hand lever at the back of the implement, and is employed to raise or lower the hoe by altering the position of the crank. The hoe frame is hung to the main frame of the implement in front by a pair of rods, each having at the upper end a small roller placed to run freely on a bar underneath the main frame, The ends of the bar are are turned round at right angles, and passed through the frame, where they are secured by nuts. Fig. 44 shows the arrangement. At the back the hoe frame is slung by two chains, one at each end. The chain rises from the frame, and passes over a small roller running in a bracket bolted to the main frame, and thence to a quadrant fixed to a shaft above, the end of the chain being attached to an eye at the back of the quadrant. Fig. 45 is a sketch of the detail. By raising a lever at one side, which may be locked at any desired point, the whole of the hoe frame may be tilted, altering the pitch of the tines. To insure regularity of work, a finger is fastened to the quadrant shaft by a set screw, and this may be secured in any position, so that if the hoe frame is tilted beyond the point desired, the finger comes in contact with the frame of the implement, and prevents further movement. The tines are mounted on a series of horizontal bars fastened each by a hinged joint to the front bar of the hoe frame, and merely resting on the rear bar; the ends of these bars are weighted so that the tine may always come down to place again if it is forced up by any obstacle on the ground. The steering gear remains to be mentioned. It consists of a long lever turning upon a pin in the main frame; the back end of this lever forms the steering handle, and the front end engages in the central loop of a jointed bar attached to the corners of the front of the hoe frame. As the latter is carried by the chains behind, and on the rollers in front, the steering is very easy and delicate.

United States of America.

In the American Agricultural Hall Messrs. Deeve and Co., of Moline, Illinois, showed their so-called "Advance" hoe, a well-finished implement, with eight broad tines arranged in two groups, each mounted in a sub-frame, hinged to the forward part of the main frame, and connected with handles at the back. These handles rest on a cross bar of the main frame, and are easily moved to and fro by the man in charge, who is thus enabled to steer the implement perfectly. The inner side of each group of tines is protected by a shield to prevent injury to the leaves of plants, between the rows of which the implement passes.

A detail may be noticed in this same hall amongst the very few implements exhibited. It is the mode of forming the blades of cultivators adopted by the Remington Company, of Ilion, New York, and is shown in Fig. 46. The tine is bent up out of a flat steel plate, and the end is partly cut away, and the rest turned round into a tube, at the end of which a screw thread is cut for the fastening nut. A washer, not shown in the sketch, fits over the open heel of the tine, and has four small lugs cast on one side of it, between each pair of which one blade of the heel goes, whilst in front there is a small central lug to enter the wood of the implement, and keep the whole in place.

A very ingenious implement, known as Nishwitz's pulverizing harrow, was exhibited by the New York Plough Company. It is shown by the small

sketch, Fig. 47, and consists of a triangular frame, with a driver's seat mounted upon it, and carrying a number of sharp-edged and concave discs, set at such an angle in relation to the line of draught that in revolving they pulverize the soil, cutting, lifting, and turning it over in small furrows. A scraper is provided for each disc, so as to keep it constantly free from dirt. The implement is said to do admirable work in mixing the soil with fertilisers. In point of construction it contains a good detail for attaching the discs shown in Fig. 48. A bolt passes through the frame, and is secured by a nut. The lower end of this bolt has an eye, in which is secured a short pin serving as the axle of the disc. The bolt runs through a cast iron cone placed under the frame, and abutting against the projection formed at the bottom of the bolt. The disc shown in section in the sketch fits loosely on the pin, and is prevented from falling off by the scraper fastened to the underside of the frame. Besides its cheapness, this arrangement has a special advantage, that of allowing a lateral movement to the discs.

Sweden.

We noticed amongst the Swedish implements one or two copies of Page's harrow, but beyond that nothing worth mentioning, and the same remark applies to the greater part of the Eastern Agricultural Hall, where some few implements of the class under consideration were scattered here and there, most of them either copied direct or modified from English practice. Amongst others are two forms of English harrows, Figs. 49 and 50. The former is Howard's well known implement, and the latter is the expanding turnip harrow of Messrs. Howard, with the tines divided into three triangular groups, each of which can be extended or contracted at will. Fig. 51 is also a familiar form to be frequently met with, the common triangular plate, with three tines, and linked together at the angles. The hexagonal pattern also abounded, in which the tines are attached in groups of three to a bar frame like that in Fig. 39.

Saxony.

R. Sach, of Plagwitz, near Leipsic, showed a hoe very much of the same type as that already described as belonging to Hornsby and Sons, but which could not compare with the latter in workmanship.

Hungary.

The most extensive exhibitor of the class of implements now under consideration was that of Edward Kühne, of Weisselburg, whose ploughs have been already noticed. Mr. Kühne showed excellent work, but the charge was brought against him that his commercial implements are very far behind those that were at the Exhibition. Besides many copies from the English makers, there were some implements having characteristics of their own. Thus his cultivator shown in Fig. 52 is a simple implement which appears in great favour in Hungary. It is built of wood, with the tines mounted on a rigid frame, and stilts behind, as shown. The only means of adjustment are those provided by the vertical screw and saddle bar—a detail which, as already seen, is employed in the plough also. Fig. 53 shows another form of harrow mounted on slades, the heights of which are adjustable, the standard on which they are mounted being locked with a key, driven in as shown. Of the several forms of crushers that in Fig. 54 is perhaps the most in favour, and Mr. Kühne, together with several other makers, exhibited them, with one or two rows of crushers, according to the size of the implement. The frame carrying the rollers is mounted on a pair of wheels with a cranked axle, which can be thrown up or down by the levers shown in the drawing. We noticed that Mr. Kühne showed a triangular-framed crusher, which approached closely to the idea of the American implement described above; but the latter had evidently not served as a model to Mr. Kühne, whose crusher consists of a series of sections of the same form as those in the ordinary crusher, instead of thin discs like the American machines.

We may mention in connexion with this exhibitor a three-roll horse roller of the arrangement shown in Fig. 55. There were three of these implements

worth noting in the Exhibition. This one, that of Messrs. Barford and Perkins, of Peterborough, and a three-cylinder implement outside the German Agricultural Hall. Of course, Messrs. Barford and Perkins's exhibit was in the English section. It is a water-weighted roller, the cylinder being made tight, and the axle running through a tube so that no escape of water can take place. Water is admitted through an opening in the roller, and the weight can be regulated at will. This same firm likewise showed a model of the road rollers, of which they have made a considerable number. They are on exactly the same principle as that just mentioned, but are mounted on a circular frame, so that in going to and fro over new works there is no necessity for turning the roller round, as the frame can be unlocked instantly, and turned around the roller. Doubtless copies of Barford's roller will be plentiful in Germany before long.

Returning to Mr. Kühne, it will be seen from the sketch that his rollers are simply mounted in a wooden frame, so that the forward roller takes a path between the following pair. The similar implement shown outside the hall was arranged just in the same manner, but the frame was of iron, and adjustable.

Of course there were numerous examples of scarifiers in this section of the Exhibition, but we think that, almost without exception, they were copied from foreign sources. The Norwegian was a favourite form, with its series of discs strung upon parallel shafts, and set round radially with spikes. There were also several of the well-known pattern, with heavy discs having coarsely serrated edges, and mounted in a similar manner.

After passing Kühne's stand there was little worthy of notice in this section. M. Vidats exhibited a few implements, but these as well as the others found in the Austrian department, presented no specialities. Outside, as was the case with the ploughs, there was a great accumulation of tillage implements of all grades of merit and demerit. Amongst them may be noted a very primitive harrow, made of short lengths of wood, strung together on bars, and with the tines bolted through the ends of the wood, as in the sketch, Fig. 56. There were copies of Ransome's, Howard's, and Page's harrows, besides plenty of harrows on heavy timber frames. There were English hoes, cultivators, and scarifiers, but no implements of novel design.

Altogether, as stated above, the show of the miscellaneous implements of tillage was a poor one, and indicated a servile spirit of imitation of English makers quite different to that evident in the plough exhibits.

Drills.

The mechanical devices for seed-sowing collected at the Vienna Exhibition were numerous rather in repeated examples, with more or less variation in detail, than in novelty of design. Amongst the English exhibitors there were scarcely half a dozen drills which were not in some degree closely related, and the same remark, of course, holds good with regard to the foreign exhibits (always excepting the American) which were largely imitated from English patterns.

England.

Immediately on entering the Western Agricultural Hall, a very ingeniously arranged and effective dibble drill (Edwards's patent) was seen. There were two, in fact, but one was a small single-chamber hand drill, the construction of which was precisely the same as the larger one, which had three chambers. This latter was made by Messrs. Page and Girling, of Melton, in Suffolk, and is very fairly executed. The drill consists of the three chambers, containing the seed boxes, cups, and barrels, mounted on a frame, which can be raised and lowered at will by a chain and wheel. This operation, common to all drills, is of course necessary at the end of the field, or when the drill is not working. The chambers are each divided into two compartments. That on the left-hand side (from the rear of the machine) is for containing the seed,

which is fed into it from a hopper in front. A shaft runs across the implement just over the seed boxes, and it can be thrown in and out of gear by a clutch. On this shaft are mounted three discs, one revolving in each seed box. Around the inner side of the disc are ranged a series of pins, at the end of each of which swings a small weighted cup, so balanced that it enters the seed-box cup first, and upsets at a constant point in each revolution. The cups are only large enough to take one large seed, but of course they pick up several if small seed is being sown. Under the *point* of their revolution where the cups upset there is a small sheet-iron hopper, which receives each seed as it falls from the cup, and the former slides through the hopper into one of a number of small chambers formed by a series of diaphragms enclosed between two parallel discs. The spaces at the periphery of the discs are closed, each by a loosely-hung valve, weighted so as only to open when they are opposite the mouth of the tube leading down to the ground. This second series of discs and diaphragms is mounted on the same shaft as that having on it the cup discs.

We have now followed the single seed, or the small pinch of seed, as the case may be, from the trough, into the cup, down the hopper, into the chamber enclosed by the discs, and thence into the drill tube. But it cannot yet get to its place in the ground which the drill coulter is cutting for it. The exit is closed with a valve, which has to be opened and shut for each seed that is picked up by the cups out of the seed box. This is effected simply as follows: The mouth of the drill tube is kept closed by a valve and spring; that is its normal condition; but another spring is added at the side, which receives motion with each seed dropped into the hopper, by means of a series of studs around the outside of the revolving disc, and corresponding in number to the cups around the inner disc working in the seed box. Each time, then, that one of these studs presses against the spring the latter forces the valve open, and the seed drops through into the groove prepared for it by the coulter, the earth falling in again as the machine advances, while a pair of iron fingers, formed like tongs, are attached to the back of the drill, and finish the operation of covering up the seed. Motion to the cup barrel is, of course, imparted through gearing from the carrying wheels. As we said, this is a most ingeniously arranged and effective implement, and it is to be regretted that the exhibitors took so little pains to call public attention to it; probably they, like a good many other mistaken and afterward disappointed people, laboured under the impression that objects, once placed in the Exhibition, would take care, not only of themselves, but of their exhibitors also.

Messrs. Smyth and Sons, of Peasenhall, were admitted by a foreign imitative majority to have the best broadcast sower in the Exhibition. It is built upon Kaemerer's patent, and the machine exhibited was numbered 12,025, a genuine index we are assured. This implement is of very considerable length, and is carried on a pair of wheels from which motion is obtained for working the seed barrels. But for convenience of transport, a transverse axle can be fitted midway, and the same wheels mounted on them, so that its breadth is thus converted into length. The seed box runs the whole length of the machine, and can be always maintained in a horizontal position by means of a screw; this is a necessary precaution in going over uneven ground. Leading from the seed-box on top are three divisions or sub-hoppers provided with sluices to regulate the amount of seed admitted. The seed barrels shaft runs through these divisions from end to end of the machine. Each barrel consists of a disc with fixed cups arranged around it on each side. The sketch, Fig. 57, shows the form given to them. It will be seen that they taper, and are so shaped as to have a cup at each end, *a* and *b*, the latter being several sizes smaller than the former. The object of this arrangement is that when the seed to be sown is very small, the seed barrel shaft may be taken out, turned end for end, and replaced, so that the small cups feed into the seed tubes instead of the larger one. On each side of the seed barrel is a small seed hopper, terminating in a tube outside the main seed-box, so that in its whole length, the machine delivers from six hoppers; the quantity delivered, however, may be diminished at will by closing two, three, or more of the small hoppers, when of course the seed fed by the cups falls down again into

the seed-box. From the tubes attached to the small hoppers, the seed falls into the broadcast distributor, a double flap hanging down at the tail of the implement, and just below the seed-boxes. The space between the outer and inner board forming this flap is about an inch or an inch and a half, and this space at the lower side of the flap is studded with wooden pegs placed at short intervals, and arranged in zig-zag rows. The object of these pegs is to distribute and divide the seed thoroughly as it falls out of the machine. A refinement in detail in the construction of this flap is worth mentioning. The upper board is hinged to the bar forming the top of the flap, and near the lower edge, between the rows of pegs, a few screws are entered, going across the space and into the rear board. The pegs are sunk into this rear board, but only butt against the inside of the upper one. This is at once a cheap mode of making, and gives every facility for repair; because if any pegs have to be replaced, the board is unscrewed and raised, and the repair made in a few minutes. The seed barrel shaft rests on suitable brackets on the frame of the machine, and is driven off the axle of the carrying wheels, on which there is a spur wheel. Change wheels are provided with the machine, to be placed on the cup barrel shaft, to gear with that fixed on the axle, and in order to adjust the level of the shaft for different diameters of wheels, blocks or discs of corresponding heights are provided to drop into the brackets for the shaft to run upon. The change wheels are also numbered to correspond with the discs, so that the men in charge have no trouble in changing the speed beyond that of selecting discs and wheels of the same number.

The next implement was one of Smyth's 14-row corn drills, in which some of the ruling ideas in the broadcast are reproduced. Thus, the seed boxes and divisions are the same as in the arrangement for keeping the box level in going up or down hill. Double cups are also used, and the barrel shaft may be reversed at will. The cups feed into small directing hoppers on each side, and the motion is given through gearing, changeable and adjustable as before. In this machine there is this important difference, however, the barrel shaft can be driven from either end, one speed being faster than the other. This is adopted because, in drilling down hill more seed is delivered than in drilling up hill, and in the latter case a quicker speed of drilling is employed.

The openings leading from the main seed trough to the smaller divisions, can be opened or closed simultaneously by means of sluices all coupled together, and actuated by a rod and handle from the end of the box. The seed, in falling on each side of the cup barrel, enters a conducting tube which forms one of the special details of the Smyth drill. It is shown in Fig. 58, and consists of several tubes fitting telescopically one within the other. The mouth *a* of the upper one is closed by the tube from the small seed hopper. At the lower end *c* there is an universal joint, so that the tube is not strained in any way by the irregular motion of the share in going through the ground. The tube is hung by chain *g* from the frame of the drill. The bottom of the tube at *e* is where the share is fixed, and through the opening of this tube the seed drops into the furrow thus prepared for it. Fig. 59 shows a side elevation of the lower part of the conductor tube, the share, and weighted lever employed to keep the share to its work, and the following roller which presses down the earth over the seed, These drills can be converted into dibble drills by the application of a supplementary apparatus, consisting of some additional gearing, easily bolted into the side of the upper box, and driven off the carrying wheels. The gearing drives a shaft, having mounted on it as many small pulleys as there are dibbles. A strap passes over these on to a similar series below, and these actuate the mouths of the dibbles, opening and closing them at the proper moment.

Fig. 60 shows a very complete arrangement, with a notice of which we may dismiss Mr. Smyth's exhibits. It is a combined manure and seed drill. The manure, phosphate, guano, or so forth, is contained in a hopper in front of the machine. This hopper is provided with suitable sluices to regulate the discharge, and has extending for its whole length a stirring shaft driven by gearing, as shown. The manure falls from the hopper into a space below, in

which revolves a long barrel, with projections around its periphery. In contact with this barrel are a series of springs pressing against it, and keeping it clean. The form and motion of the barrel throw out the manure in suitable quantities into the hoppers shown in the sketch, whence it falls through a series of cones into the furrow prepared for it by the share. Then follows the seed, distributed in the same manner as in the simple drill; and, finally, the wheels succeeding each drill cover the ground over and complete the operation.

Messrs. B. Reid and Co., of Aberdeen, exhibited an eleven-row drill of a different construction. There are no cups employed, but instead a shaft runs through the seed-box, in the bottom of which there is a series of holes, corresponding in number to the drills in the machine. These holes can be closed simultaneously by a *long* slide, or any number of them may be shut off by transverse slides. When the drill is in operation the discs on the revolving shaft feed down the seed into the conductors, and thence into the ground. One other point in this drill is worthy of note, namely, the arrangement for lifting the drills out of work. They are raised by a chain and large wooden axle, as usual, but the motion is regulated by a reversing lever, the detent of which engages into notches in a disc around the centre of the shaft. Besides this machine, the same maker showed a small combined drill and manure distributor. In this the common cups and barrels are used, and the manure is contained in three vertical conical hoppers, with revolving stirrers, forming an ingenious but futile device for regulating the supply of manure.

Mr. James Coultas, of Grantham, showed a Smyth's broadcast with iron pins instead of pegs in the distributing flap. In all respects this was an inferior machine to the one already noticed. A screw motion for raising and lowering the cup barrel shaft is employed, instead of the mode used by Smyth.

Some little space may fairly be devoted to a notice of a novel, and we are assured a very practical, drill for potato sowing, of which an illustration is given in Fig. 61; but some of the details of which differ slightly from those in the machine actually exhibited. The hopper is large. and in two compartments, with a wooden grid bottom, and the openings from it are governed by sliding gates. The grid bottom of the hopper is kept constantly in motion by an eccentric worked off the motion shaft. Two shafts, one above and one below, have upon them each a pair of wheels, the plane of which corresponds to the centre of the hopper opening, while a third pair of independent wheels complete the circuit, around which traverses an endless band, with large wooden cups fastened to it. As the band travels each cup takes up a potato and carries it up to a higher level, when it drops it down a conducting tube, and the potato falls into a groove made by a share, of which there are a pair on the machine, so that two rows of potatoes are planted at a time. Two covering mould-boards and some tines at the rear follow, and close the soil over the potato. This is a well made machine and is arranged so as to be adjustable in all directions.

The last of Mr. Coultas's exhibits to be mentioned is a small dibble drill arranged like Smyth's, but with a peculiar dibble, consisting of a circular iron casing containing a cup wheel. This wheel is mounted on a spindle running through the casing, and on the outside is a small pulley, which is driven off a spindle, as in Smyth's dibble, causing the recessed or cupped wheel to revolve, and to deposit at the proper intervals the seed which each cup contains. Fig. 62 is a sketch giving an approximate section of this detail. The seed is then covered in the usual manner. This arrangement of dibble, which is simple, is siad to answer well, and to find much favour in Austria and Hungary.

Messrs. R. Hornsby and Sons showed a well-made 15-row drill, with cup feed, and nothing special in the general arrangement. They close the sluices from the seed box simultaneously from the centre, instead of at the end, as Smyth does, and the body of the machine is mounted in a manner peculiar to these makers. Spindles project from the ends of the body, and are connected with a small screw-jack bolted vertically on each side of the

frame. By working these jacks together, the body of the implement is raised to any desired height. On the cylinder of the jacks is a graduated scale numbered to correspond with the change wheels, so that, for a given speed, the men in charge can regulate the position exactly, before putting the wheel on the barrel shaft. There are also two toothed wheels of different diameters on the driving axle, by which the speed may also be regulated, and the end of the barrel shaft above is made square to receive the wheel gearing into one or other of the former. A nut is placed at the end of the shaft, and a sliding collar, the width of one toothed wheel, is placed on the square part of the shaft. The length of this square part is double the width of the wheel, so that in putting on the change wheel to gear either with the larger or smaller one on the driving axle all that is necessary is to shift the collar backwards or forwards, as the case may be (see Fig. 63).

The most distinguishing feature about this machine is its steering gear which is ingenious and well designed. To avoid the inconvenience and uncertainty of steering by dead pressure against the front bars of the machine, Messrs. Hornsby have introduced a second bar behind and parallel to the first. On the front bar, and about midway between the central pole, and the end of the bar, is hinged on each side a segment rack. These racks fold up close to the bar, and their ends rest on a bracket placed just at one end of the pole. On the second bar are mounted two guides and a small bearing. Between the guides the segment racks are placed, and a pinion fast on a pin and crank handle is put into the socket coming in gear with the rack. Of course only one rack is employed at a time, and according to the direction of the work, the right and left hand racks are alternately put in gear, and folded back on the small bracket plate over the pole.

The same firm exhibited a manure distributor, the hopper of which is mounted in a similar way to that described for the drill; the openings from the hopper are regulated by sluices also in the same manner, and the manure is finally thrown into a broadcast distributor like that in Smyth's sower, but on a larger scale.

Messrs. Garrett and Sons had a number of drills at their stand, all of them of the same pattern, and presenting no peculiarity of detail. The hopper sluices are opened and closed by a pinion and small quadrant rack, and a universal joint is added to the seed tubes. The work on these implements did not come up to the average standard of the other makers.

United States of America.

In the American Hall, two makers, Messrs. Thomas and Mast, and Messrs. Ludlow and Co., both of Springfield, Ohio, showed each a combined drill and broadcast for clover, &c. In these implements the barrel shaft is below the seed hopper, which has a number of small holes at the bottom, corresponding to the number of drills, and the cups are formed in wheels mounted on the shaft, and revolving in such a way as to take a small quantity of seed in each cup and drop it into the tube. The broadcast comprises an independent hopper on the side of the other one, with a notched board within it, and extending for its full length working to and fro by means of a connecting rod and crank on one of the geared wheels; the notches alternately cover and expose holes in the hopper leading out to short sheet-iron sills extending the length of the hoppers. From these sills the seed is scattered on the ground. This is in Messrs. Thomas and Co.'s machine. In the other the arrangement is similar, except that the sill is continuous, which is an improvement. There are a variety of ingenious details about these machines which, as they are never likely to prove useful to English makers, need not be noticed.

France.

Drills were represented in the French Agricultural section by a single and singular specimen, devised by M. E. Palaute, of Arras. It is a broad and

cumbrous machine, with a a pair of handles behind. From a pair of carrying wheels proceed connecting rods, attached to crank pins in the former, and taking hold of cranks on the end of the barrel shaft at the rear face of the seed box. This latter is hinged in front, so that as the machine is drawn along, the combined action of connecting rods and hinges is to turn the shaft and agitate the box by lifting it up and down. What was inside the seed box we do not know, but the conducting tubes are of cast iron with a row of lugs cast upon one side, by which their level can be adjusted as they stand, in a series of holes in the frame, and are retained by a loose collar.

GERMANY.

In the Eastern Agricultural Hall, the Eckert Manufacturing Company of Berlin are again the first to receive attention. They exhibited only two machines for seed sowing : one a drill and the other a broadcast. The frame and carriage of the former call for no special notice, except that the hubs of the carrying wheels are made in halves bolted together, the division being in a vertical plane, so that each half is recessed to receive half the width of the spokes, as seen in Figs. 64, 65, and 66.

The openings leading from the seed box of this machine can be closed by a continuous slide, moved up and down from the outside of the seed box, or one or any number of the openings can be closed at will by independent slides worked separately. The cup barrels are arranged differently to any met with in the English department, and somewhat resemble the mode adopted in the two drills exhibited in the United States Agricultural Hall. Fig. 67 shows a side elevation and sectional plan of a cup wheel, but differing somewhat from those exhibited, the ratchet-like projections not being used, and the cups merely recessed around the periphery of the wheel, which thus shows an unbroken circle in side elevation. For different seeds, wheels of varying diameter, and recessed with cups of different sizes, are employed. Fig. 68 is a section through seed box, barrel chamber, and distributing tube. The seed box is formed with a ridge and furrow bottom, the position of the holes corresponding to that of the furrows. The small pinion working into the rack is employed for raising and lowering the slide. In the machines exhibited, the arrangement was somewhat different, the continuous slide being on the inside of the seed box. The cup wheel, mounted on the shaft, as shown, revolves between a pair of cheeks, which serve to confine the seed passed from the box in close proximity to the cup wheel. A small valve directs the seed into the tube through the nozzle, which forms a part with the bottom of the barrel chamber. It will be noticed that Smyth's telescopic conducting tubes are employed with the universal joint. The arrangement of the coulter, the balance weight bars, and forward frame bar, need no description.

The broadcast sower shown by the Eckert Company was a very long one, with transverse axle, for transport, the same as seen in Smyth's. The seed box is provided with a ridge and furrow bottom, and is fitted with a shaft and bent discs, exactly upon Page's system, already described, and illustrated by Fig. 69. The arrangement has this improvement over Page's, however, that the holes in the bottom of the seed box are all controlled by a plate with perforations in it corresponding to the holes in the bottom, and this plate is connected with a horizontal lever moving upon a graduated segment bar, so that the holes can be entirely closed, or the amount of opening may be regulated with the utmost nicety. The distributing flap is very narrow, as compared with that of Smyth, and rows of wire pins, instead of wooden pegs, are employed as in Coultas's broadcast, an arrangement which, as already said, is far inferior to the ingenious detail of Smyth's hinged flap, before described. We believe that this broadcast is the favorite form employed in North Germany, and that, in justice to Mr. Page be it said, the disc feeding system answers admirably.

Both the machines we have described showed first-rate work, and in all respects, sustained the reputation of the Eckert Company.

SAXONY.

Rud. Sack, of Plagwitz, near Leipsic, showed a manure distributor, well made, and not at all badly designed. Fig. 70 shows an approximate sketch of the arrangement, from which it will be seen that in the large manure hopper are contained two shafts, armed at short intervals with tines. These shafts are coupled together at the end to a central spindle, by turning which a reciprocating motion is communicated to the shafts. Lower down, near the openings between the ridges and furrows in the bottom of the hopper is a third shaft with bent tines; a revolving motion is imparted to this shaft. By the united action of the three shafts the manure is well mixed, and fed through the openings, duly provided with sluices, on to the distributing wheels, which have a semicircular recess around the periphery. In connexion with these wheels are a series of scrapers, of the form shown; the manure falls through a tarpaulin distributor, and the cover of the manure hopper is also of the same material, though why this is used in preference to a wooden flap we do not know.

Mr. Sack also showed a drill with cup wheels, something like Eckert's, but the machine in all respects falls short of that exhibited by that company.

Mr. W. Rappsilber, of the Theresienhütte, near Falkenberg, had a well-made broadcast which looked a little as if it had been got up for exhibition. It had a ridge and furrow bottom to the seed box, and precisely the same arrangement for closing the holes as in the Eckert broadcast, namely, a continuous bar, and a central lever and graduated segment bar. Instead, however, of employing Page's discs on the feeding shaft, he mounted a small wheel with some paddles upon it to feed the seed through. This arrangement, we should say, cannot give anything like such good results in working as the Page discs. The distributing flap of this machine is still narrower than Eckert's. Iron pins are used in it.

Heinrich Friedmann, of Ratibor, exhibited a manure distributor on Hornsby's system, and a broadcast with paddles in the seed hopper like Rappsilber's, only larger. Fig. 71 gives a sketch of their approximate form and arrangement.

T. Dee, of Halberstadt, in Prussia, had a manure distributor, like that of Smyth's, with the ribbed shaft and revolving pallett scrapers, as well as the numbered dies for the change wheels. He exhibited also a 13-row drill, Smyth's system, and with nothing special to be commended in point of workmanship.

We must spare a word in passing for a drill exhibited by A. Mackean and Co., of Breslau, which, apart from costly and bad workmanship, contained some of the most stupid details of any machine in the Exhibition. It was a large drill with cup barrel, and small seed hoppers like Smyth, and Smyth's ball-and-socket joint to the distributing tubes has also been copied. Originality, however, declared itself in the arrangement for raising and lowering the coulters and distributing tubes. These, instead of being wound up by chains passing over the transverse axle provided for that purpose, were indeed attached thereto, but the axle itself rises and falls, climbing up and down a segment rack, the motion being provided for by suitable mechanism. The gem of mechanical genius was, however, the detail for levelling the seed box. Fig. 72 shows a sketch of it, for it is too good to be lost. The back of the seed hopper is shown at *a*, and a part of the fore carriage at *b*. Bolted to this is a standard with a nut upon it through which passes the screwed end of a long shaft *c* with a crank in the middle, and an eye at the other end, pinned to the seed box between two brackets. By turning the shaft, which, by the way, is about 5 ft. in length, the position of the seed box is regulated. There was a good deal of costly and unnecessary work in the hanging of the coulter bars, and altogether, while there is so much to be said in condemnation of the machine, not a single point can be raised in its favour.

The same makers also showed a better designed and finished drill, with no speciality of detail, if we except the steering gear. The pole is provided with handles at each end for steering by dead pressure, but in addition there is mounted on the fore carriage a vertical shaft with two chains attached to it. The opposite ends of these chains take hold of the fore carriage frame, and

by turning the wheel with the steering lever the direction of the machine is easily and perfectly controlled.

Messrs. Främbs and Freudenberg, of Schweidnitz, in Prussia, exhibited two drills, one called a dibble, but showing no arrangement for checking the deposit of seed. This machine has only three cup wheels of the Eckert pattern, feeding down distributing tubes with rollers in front of the coulters. The seed box in this and the larger machine is levelled by means of a hinged segment rack and a pinion worked by a lever in front of the box. In the larger machine, a very round-about way is adopted for using the cup barrel shaft. On one side is an internal geared wheel attached to one of the carrying wheels of the machine. This drives a pinion mounted on a shaft passing under the front of the seed box, and having another pinion at the opposite end which gears into a toothed wheel on the barrel shaft. Both design and work in these machines was inferior. An elevating and depressing screw in the fore carriage may be noted.

Messrs. Maultzsch and Co., of Zschöllaub, near Oschatz, had a 16-row drill on the Eckert model, with a shaft and quadrants for raising the coulter bar, and the driving gear carried on a light frame at the end of the machine, and controlled by a lever in such a way as to be easily thrown in and out of gear.

A somewhat similar arrangement of driving gear is adopted by Messrs. Siedersleben and Co., of Bernberg, who showed several drills, including a dibble, a little after the type of Edwards's dibble, already described, but not so good. In the front of the machine and about at the level of the top of the coulters, is a shaft carrying a number of small discs with studs around their peripheries. This shaft is driven by gearing from the main axle, and in revolving the studs on discs press intermittently upon springs connected with the seed traps behind the coulters; this pressure opens the traps and the seed falls, but ceasing, the spring closes the opening until the next supply of seed fed in from the cup on the discs in the seed box above enters the trap through the distributing tubes.

We may devote some attention to the machines of this class shown by Messrs. F. Zimmerman and Co., of Halle-on-the-Saale. This firm exhibited very good work, and originality in design.

We may first take their manure distributor, which has a continuous series of pallett wheels like those in the Smyth distributor, and against them press a number of scrapers, which, however, are not springs, but are simple plates hung on a shaft, and each carrying behind it a short lever and small weight which keep the face of the scraper always in contact with the pallett wheels. The sluices of the manure hopper are closed simultaneously by a lever, and the hopper itself is levelled by means of a cranked lever, worm gear, and rack. The pallett wheel shaft is driven by gearing in the ordinary way, and at the opposite end of the shaft is a bevelled wheel, gearing into a second, which gives motion to a small connecting rod, taking hold of a bar under the front of the manure hopper, and which, by this means, is moved to and fro, for agitating the manure. The distributing flap of this machine has a very broad opening at the bottom, and a canvas screen is added, hanging down almost to the ground, to prevent the manure from being scattered. The fore carriage of this machine is framed with angle iron.

The two drills shown by this firm were also well executed. A peculiarity of detail is shown in Fig. 73. From this it will be seen that the coulter blade may be removed at any time and easily replaced. Distributing tubes with two ball joints, Fig. 74, are also employed. In both drills a shaft with two quadrants are employed to raise the coulter bars.

Bohemia.

Mr. Julius Carow, of Prague, exhibited several drills and a broadcast, all on the Smyth system but with work decidedly inferior to that in the original from which he has copied.

Bernard Eichmann, of Prague, showed some passably good work in Chambers's manure distributors, and some of Garrett's drills. He also showed a broadcast with cups mounted on discs, and in all respects an ordinary

pattern. The only speciality we may notice, and of which only one or two more examples were found in the exhibition, is a dibble, somewhat of the same type as that attached to Coultas's drill, and already described. The large seed box is divided into four separate hoppers, and from each of these the seed drops into a box below. The bottom of this box is in communication with the seed cup wheels, which are large, and revolve upon one shaft driven from the gearing on the carrying wheel. In the periphery of these wheels are formed a number of cup recesses, to receive the seed as it falls from the boxes above. The fronts of the wheels are sheathed by close-fitting cases, so that the seed in being carried forward cannot fall out until it reaches the opening in the bottom of the sheath, which is close to the ground. This arrangement is simple, but does not appear so efficient as the rotating dibble on the Coultas's machine.

Austria.

Sigl of Wiener-Neustadt exhibited several copies of Messrs. Garrett's drills, which were very largely copied by all the foreign makers. Mr. J. Kugler, of Vienna, had a four-row dibble on the same principle as that exhibited by Eichmann and already noticed. Mr. Kugler's machine, however, was executed in a superior manner. The cups in the wheels are of a different form, being about as shown in the sketch, Fig. 75.

Fig. 76 is a detail of the mode adopted by Mr. Kugler in driving this drill. The spur wheel *a* is mounted on the main axle. The wheel *b* is on the end of the cup wheel shaft. The lever *c* carries at its lower end a small bracket on which a third toothed wheel *d* is mounted, so that by a movement of the reversing gear the machine can be put out of operation. For this special class of drill, with the cup wheel shaft below the main axle, the mode of driving adopted seems to be a good one.

It is scarcely worth while giving the names of the several makers between this last stand and that of Messrs. Garrett, who showed copies of the latter's machines. Of Messrs. Garrett's exhibits all we need say is that they were excellent in workmanship, and judging from the respective exhibits, the firm at Buckau can give the English firm some useful lessons in turning out good work. Messrs. Clayton and Shuttleworth showed their 13-row drills with cup discs, the design and appearance of which came up to the high standard of the rest of their exhibits.

Hungary.

Some very poor work was shown by a Hungarian firm, who exhibited a few drills, of which the novelties consisted in levelling the seed box by an inclined screw shaft, connected to the top of the seed box, and the bar of the fore carriage. This is not a good arrangement, but one far preferable to the corresponding detail by Mackean. A second Hungarian maker exhibited an undoubted curiosity in a drill built entirely of wood, excepting the cup wheel shaft and coulters. The cup wheels were of the ordinary pattern, like Eckert's, varying according to the nature of the seed, some having serrated, and others shielded cups. The hopper was large, and the openings controlled by independently worked sluices. On the inside of the front board of the cup wheel chamber, and opposite each wheel, were a series of small hoppers to receive the seed as it falls from the cups. Below each hopper was a square conductor, and funnel leading to the fixed tube attached to the coulter. The driving gear of this machine was of wood, and had no means of adjustment. It was altogether a singular instrument, but one from which satisfactory work or duration could be expected.

Edward Kühne, of Weisselburg, showed some very good copies of Garrett's drills, and Vidats, of Pesth, had three or four machines, calling for no special notice, if we except a form which has been abandoned long since in England, and of which we give a sketch in Fig. 77, as illustrating what appears to be considered a novelty by the Hungarian manufacturers. It consists of a bar carried by two adjustable wheels, and a cross frame for the leading wheels; stilts form the continuation of this frame. On the bar are mounted three or more hoppers, connected with distributing tubes, and coulters below. On a

shaft above the hoppers, and corresponding in number to them, is a series of spheroidal chambers made in iron, and around the periphery of which are formed a number of holes, the sizes of which can be adjusted by a suitable slide. Any of the holes can be closed at will. The shaft and chambers are driven, as shown, off a strap from the pulley on the leading wheel shaft, and the seed is thrown out through the holes in the chamber and fall down the hoppers into the tubes. The action of these machines is very uncertain and imperfect, and they are very liable to interruption through the holes becoming stopped.

Messrs. Zavar and Stoye, of Oedenburg, had one or two Garrett drills, and in one example they exhibited the mouths of the small distributing hopper project outside the seed box, the upper end of the distributing tubes being just below. There appears to be no advantage in this arrangement, and the seed is unnecessarily exposed to the wind.

One exhibitor, from Magyarorszag had a neatly made drill with a row of seven chambers like those alluded to as exhibited by Vidats, mounted on one shaft, and running within a large box. The delivery to the tubes is of an ordinary character. The shaft is driven by a strap off a pulley on one of the carrying wheels. A manure distributor (Chambers's) was shown by Umrath, of Bubna, near Prague.

Russia.

Ladislaus Mencel, of Bialazerkoff, in Russia, who showed good work and originality in all his exhibits, had several drills, which merit a somewhat detailed description, as they were the first of the class met with in the Exhibition, although, by the way, Messrs. Lilpop and Rau, of Pesth, showed several upon precisely the same principle.

One of Mr. Mencel's exhibits was a machine which can be employed either as a broadcast or a drill. In the former case the distributing tubes are removed, and the broadcast flap substituted. This latter is not provided either with wooden pegs or iron pipes, but has a series of rows of triangular bars arranged as in the sketch (Fig. 78).

The seed box is divided into as many hoppers as there are points of discharge, and at the bottom of each is a square opening, leading to a second series of small hoppers which pass the seed direct into the distributing tubes either of the drill or the broadcast.

Fig. 79 shows a rough sketch of the arrangement adopted for an intermittent feed in these machines. The large hoppers are shown at *a*, and the small ones leading direct into the distributing tubes at *b*. In the vertical side above the hoppers *b*, are the square holes *c c* through which the seed passes into these hoppers. On the shaft *e* are mounted brass slides *d* with holes in them corresponding with the holes *e e*. By these the exact size of the seed opening can be regulated, the whole of the slide being actuated simultaneously by a lever in the centre of the machine, and the amount of opening is indicated by an index, attached to the shaft and turning around a graduated dial. On a lower shaft *f*, are mounted a series of sliding shutters *g g*, which receive a reciprocating motion, alternately opening and closing the holes *c*. This motion is effected by means of a cam mounted on the same shaft as the toothed wheel driven by the gearing on the main axle of the machine. Each of the coulters has attached to it a dragging bar, for closing the earth over the seed. The coulter bars in these machines are lifted by a cross bar which has a long bent lever attached to it, and the end of which, when thrown up, engages in a latch detent, in the side of the seed hopper, and is held fast.

Messrs. Lilpop, Rau, and Co., of Warsaw, showed, as we have said, several drills with exactly similar details as those just described. One of these was a very large four-row drill, with a screw adjustment in the centre for setting the position of the brass shutter. On the shutter shaft are two small fingers with forked ends; the forks engage in the bosses of two independent nuts with milled heads, mounted on a screwed spindle. By turning these in either direction any adjustment desired can be obtained. In the smaller drills, one of them an 11-row, an arrangement similar to that of Mencel's for

raising the coulter bar is adopted, but in the larger machine, just noticed, the coulters and tubes are raised by being wound round a chain on a wooden axle, handles being placed at the extremity of the axle for that purpose, and a ratchet wheel mounted upon the axle engages in a pawl, which arrests its return.

An examination of the seed-sowing appliances exhibited by foreign makers showed, with two or three exceptions, but little useful originality, the large majority preferring to make copies, and very bad copies in a few instances, of English machines. While this fact enhances in one sense the value and appreciation of these machines, on the other hand the bad copies which are so freely sold, do much to bring them into bad repute, and more than one first-class English maker, has before now found his trade, in certain districts, almost spoiled, because his so-called machines had earned a bad name, and no purchasers would believe that there was any distinction between the genuine implements and the forgeries. As, however, a thorough appreciation of good work becomes more general, and manufacturers like Garrett of Buckau, and Clayton and Shuttleworth of Vienna, as well as the several firms who export largely from England, are constantly educating purchasers on this point, the clumsy imitators will find in the course of a short time but a poor market for their goods, and they must either abandon the competition or introduce a different class of work. Judging from the samples exhibited, this appears difficult except for the foreign firms which enjoy deservedly a high reputation.

Taking everything into consideration, we should imagine that English manufacturers of seed-sowing implements will, for many years to come, keep the position they possess in the foreign trade, and indeed it should improve, because, imitating manufacturers must always follow originators at a considerable distance, and purchasers are constantly more judicious and critical in their selections.

Haymaking Implements.

But very few exhibits of haymaking implements were to be found either in the eastern or western Agricultural Halls, whilst those which were shown in the former indicated a marked want of progress even in imitation.

England.

Messrs. J. and F. Howard, of Bedford, had beyond all comparison the best collection of these implements, comprising two horse rakes, and two haymakers, all of the most recent patterns. The latter class, indeed, was only represented by two other makers, Mr. W. N. Nicholson, of the Trent Iron Works, Newark, and Mr. R. Boby, of Bury St. Edmunds. Fig. 80 gives an illustration of Messrs. Howard's larger size of haymaker, and indicates the construction sufficiently, until we publish more detailed drawings. It is an iron-framed implement mounted upon three wheels, with a seat for the driver, and, if required, a wire screen to prevent the grass from accumulating on the carriage. The larger wheels contain within the casing shown around the boss, a fast spur wheel which, of course, revolves as the machine advances. At the rear, on each side is an eccentric casing, containing a pinion fast on a through shaft, and an intermediate loose pinion, always driven by the spur wheels attached to the main wheels of the carriage. The through shaft upon which the pinions are mounted, rests at the ends in eccentric bearings formed in the casings before mentioned, and by turning the shaft it its bearings by means of a lever the pinion can be thrown into gear with the spur wheel, and motion is communicated to the shaft. Again, if it be desired to drive the shaft in the same direction as the advancing machine, the eccentric bearings can be thrown over in another position, and geared into the intermediate pinion which is always driven from the spur wheel. The first pinions are not fast on the eccentric shaft, but form a part of the revolving rakes which are mounted upon the shaft, and turn around it. There are two sets of these rakes, each having six arms, and every arm being provided with three tines. The arms are arranged so as not to range with each other, and the tines are

curved as shown in the sketch, in order that when going in one direction the hay may be agitated as much as possible, and merely laid over when the motion is reversed. A spring arm forms a part of each rake, which presses against the head carrying the tines, and keeps them up to their work, but allowing them to yield to any sudden obstruction.

The means employed for raising or lowering the rakes with the shaft upon which they are mounted are very simple, consisting merely of a rod on each side of the machine, pinned upon the wheel box at one end, and terminating in an eccentric strap round an eccentric at the other, upon the frame of the implement. By turning the lever shown the position of the eccentric may be adjusted as desired, and the rakes and connexions rise or fall, the pinion turning round the spur wheel without their relative positions being otherwise altered. In the smaller haymaker this adjustment is omitted.

The haymaker of Mr. Boby we may dismiss with a few words. It is a well-made implement with two sets of revolving rakes, driven from the carrying wheels, the heads of which are checked by springs, and which are mounted on a shaft to the rear of the centre of the carrying wheels. Inside a casing are a pair of spur wheels, one on each side of the machine, and at the rear of the same casing are two pinions, for altering the motion, sliding to and fro upon an independent shaft. By changing the position of these pinions, by means of a small clutch lever, the machine may be put in or out of gear, one pinion engaging in driving wheels, and the other in the spur wheel on the rake shaft.

An illustration of Mr. N. Nicholson's haymaker is shown in Fig. 81. This implement is well and very widely known. The driving gear consists of an internal and external spur wheel, attached to the main carrying wheel inside a box, as shown. The smaller of these *a* is nearly flush with the front edge of the wheel box *c*. The latter is formed at the back of the box. The rakes are mounted on two independent shafts, coupled by a central sleeve *a*, Fig 81, and free to slide to and fro. At each of the outer ends of these shafts is a pinion which falls into gear either with the spur wheel *a*, or the interior gearing *b*. In the former case the motion imparted to the rakes is the reverse of that of the machine, in the latter it coincides with the progress of the implement. Close to the pinion, and on the shaft, is a collar, and in the casing round is a hinged casing, the underside of which is formed with suitable recesses. According to the position of the shaft, either for backward and forward motion, or when out of gear, the grooves in the casing close over the collar and prevent lateral movement. The rake heads are attached by screws to the arms of the implement, and a spring bearing against them keeps them to their work, but allows them to yield before any obstacle.

The arrangement altering the set of the rake is similar to that employed in the horse rake, and will be noticed presently. Mr. Nicholson exhibited also a larger machine, with an extra motion, so that fast or slow backward or forward movement can be obtained. This appears an unnecessary refinement. The set of the implement is regulated by an arm carrying a toothed segment, and gearing in a pinion on the fore carriage.

Miscellaneous.

Amongst the rest of the agricultural exhibits there were only two haymakers, a very fair copy of Howard's small pattern, by F. Dehne, of Halbestadt, and one, a very crude implement, by M. Cossimini, of Grosseto, in Italy.

Horse Rakes.

England.

Turning now to the horse rakes, we may again commence at Messrs. J. and F. Howard's stand. They exhibited two implements of different construction, which are shown in the sketch Fig. 82. In the smaller and simpler of these rakes a straight steel axle runs through the machine,

carrying the wheels and the shafts, and forming a fulcrum in raising the teeth of the rake. When, however, the teeth are down to their work they are quite clear of the fulcrum bar, and being hinged to the forward bar, are free to rise and fall according to the inequalities of the ground. The arrangement of levers for raising the rakes is shown in the drawing. To a plate attached to the cross-bar of the fore carriage is connected a radial bar, the length of which can be adjusted by means of a series of holes in the end of the bar and a pin. The long lever terminating in the handle, as shown, is connected with the radial bar, and on being pulled down turns the forked rod and long cross-bar attached to it, the latter turning on centres corresponding to those of the wheels, and depressing the rods *f*, *f*, attached to the bars carrying the ends of the teeth. This bar is, of course, also depressed, and the teeth resting on the steel axle bar, are raised to any desired height. A small hook on the rear of the frame and close to the upright guard *g*, is thrown over the lever *c*, when the latter is depressed to its greatest extent, and the teeth of the implement are kept clear of the ground. The locking arrangement consists of a shoulder on the depressing screw, which abuts upon the radial bar.

We should call attention to the mode employed by Messrs. Howard for securing and mounting the teeth of their rakes. The teeth are coupled together in pairs by a small bar frame, as shown in the sketch, Fig. 83, each tooth being bolted to the frame, and terminating in a hook through which the bar of the implement passes.

Messrs. Howard & Co. exhibited also a large automatic rake, of which they make a large number. In this the frame holding the teeth has mounted upon it a shaft, with a small lever attached to it at each end. On the carrying wheels are drums around a groove, in which passes an iron strap with the ends fastened to the levers on the cross shaft. In the centre of this latter is a bar, by depressing which either by the foot in front, or by hand behind, the strap is tightened on the disc, and the rake frame becomes rigidly fastened to the wheels. On releasing the lever the teeth, of course, drop. On the pedal bar is a finger, in contact with a hanging rod provided with a hook at the end. When the rake is in action the hook falls under the shaft carrying the teeth, and forms a lock; but in depressing the pedal the finger before mentioned forces back the hanging rod, so as to clear the shaft before the teeth begin to move. A second hook is added to the implement for retaining the rake frame in its highest position when it is not in use.

Messrs. Ransomes, Sims, and Head, of Ipswich, showed one excellent example of a horse rake, which combines many good details. The implement is shown in Fig. 84, and it will be seen that the teeth are of a ⊥-section. The method of mounting the teeth is very good. The end enters a suitably-formed socket, through which a bolt passes, and over this bolt the end of the tooth is hooked. The sockets are, of course, all mounted on one bar, which is raised and lowered by a lever, as shown, the fulcrum bar being also clearly indicated in the illustration. In the machines provided with a seat, the rakes can be worked either by a hand lever in front or with a pedal, for as the teeth are admirably balanced the work is very easy. The shafts of the implement are attached to the frame, as shown, and a means of adjusting the set of the rake is provided by the segment bars at the rear of the shaft. The rake can also be raised or lowered by means of the levers and toothed segments at each end of the frame. It will be noticed that the transverse stay bars are not straight, but all curved to correspond with the contours of the teeth.

Mr. Nicholson's rake merits description. He does not employ a solid axle, but uses two semicircular bars, placed as shown in the sketch Fig. 85, and at a sufficient distance apart to permit the different fastenings for the frame and levers to be placed between. The wheels are mounted on chilled cast-iron bosses attached by bolts to the ends of these bars. The driver's seat is carried by a couple of bar supports, fastened to each end of the axle, and the vertical rods go from the underside of the seat to between the pair of axle bars, where they are secured by adjustable nuts. The teeth are fixed in cast-iron sockets, half-round recesses being made both in teeth and socket, with a vertical pin driven in. The axle bars serve as a fulcrum to raise the teeth, and around these bars turns a cast-iron cranked lever, one end being attached

to the teeth shaft, and the other to a system of levers terminating in the depressing handle. The locking gear is shown in Fig. 86, where *a* is the rod from the cranked levers, and *b* the end of the depressing lever. The quarter-round ends *c*, *c*, of these bars abut against each other when the teeth are in their highest position, and form an efficient lock.

Fig. 87 shows the detail for altering the set of the rakes. The frame bar has a rounded end *a*, with serrations on the inner side, corresponding to similar serrations on the piece *b*, fastened to the bar of the fore carriage. By slacking the nut *c* the block *a* can be turned, and the angle of rake altered.

Messrs. E. Page and Co., of Bedford, showed a horse rake of their usual pattern, with the drivers seat at the back of the implement, and a lever within reach for operating the rake. The teeth are flat and rounded in section, and are bolted to the cast-iron sockets mounted on the bar. The fulcrum for the lever is on the cross-bar of the fore carriage, as in the smaller of Howard's machines, and is connected to a bent and jointed lever which elevates and depresses the teeth. On a standard is placed a regulating screw, which, coming in contact with the lever, regulates the movement and alters the set of the teeth.

Mr. T. Weetman, of Ipswich, whose death occurred during the period of the Exhibition, showed three horse rakes, of fair workmanship, and some specialities of detail. The first of these implements had attached, near the ends of the main teeth, a second series of intermediate teeth, which could be used at pleasure for special work, or for preparing the ground for sowing clover or other small seed, a box for which, containing a shaft, with revolving brushes upon it to distribute the seed through openings in the box. Hinged to the same bar as the teeth, and in such a way as to exert their weight upon the latter, are a number of small balance-weights, which, when they are extended, reduce the pressure of the teeth upon the ground, and make them more susceptible to rise; on the other hand, by turning the weights back over the top of the teeth, a considerable additional pressure is obtained. The row of teeth are raised by a simple combination of levers, either from the ground or the carriage seat, whilst, if the second series of teeth are removed, the rake is light enough to be operated by the foot. A second rake is similar in general arrangement to the first, but has only one set of teeth, and is not intended to act as a compound implement. Balance weights are added to the teeth, but they are fixed. The third rake resembles the one first noticed.

Sweden.

In the Swedish department there was only one from Ofverum—a very second-rate copy of Ransomes' implement. Another copy from the same original was in the court outside the Eastern Agricultural Hall.

Germany.

Near the imitation of Howard's haymaker by Dehne, of Halberstadt, and by the same maker was a neat horse rake, with V-shaped teeth, fastened by hook bolts to cast-iron blocks, with V-grooves, in which the roots of the teeth rest. The wheels are mounted on vertical bars, sliding in brackets on the sides of the frame, and are raised or lowered by means of a lever, locking in a toothed segment plate. A bar extends from end to end of the implement under the teeth, and is connected by two chains to cranks, one at each extremity of the way shaft, in the centre of which is mounted the long lever for depressing and raising the teeth. When the lever is quite down it is held by a hook at the back of the frame. The way shaft is carried on bars bolted to the frame.

Messrs. Rapp and Speises, of Goepingen, showed a somewhat similar implement, but the teeth are rectangular in section, curved bars, in fact, the upper part being quite straight. The frame of this implement is partly of cast iron, and the wheels are attached to it without means of adjustment.

Miscellaneous.

Mr. H. Kuhne, of Weisselburg, showed a rake of similar arrangement, which, indeed is the general type of the few implements of this class exhibited

in the Eastern Hall. The teeth are attached to the sockets, by having a slight recess cut near the end, and a strap passed around the tooth and through the socket, being fastened by a pin on the other side.

Messrs. Lilpop, Rau and Co., of Warsaw, adopt an operating lever like that of Page's; the ends of the teeth in their implements are formed with eyes, by which they are bolted through to the sockets. The frames are of wrought-iron, and the wheels are mounted on bars in sliding blocks, and adjustable by set pins.

Of the few horse rakes in this part of the hall remaining to be noticed, those of Clayton and Shuttleworth, of Vienna, were the most conspicuous. They are beautifully made, and have formed the models for many other foreign makers. The teeth are fastened to the sockets by strap bolts, and they are lifted by means of a system of levers, with adjusting holes, in the rods attached to the elevating bar.

Karl Studel, of Raab, in Hungary; F. Spielvögel, of Sandhübel, in Austria; and Hopherr, of Vienna, all exhibited implements of this class.

Heinrich Lanz copied Howard's rake, but not his last pattern, in which the teeth are mounted in pairs, the attachment adopted being shown in the sketch, Fig. 88. Finally, we may mention Messrs. Gamen and Turner, of Hanover, who showed a well-made horse rake, with a somewhat original system of raising and depressing levers.

The foreign makers showed less promising exhibits, taken collectively, than they made with the drills, most of them being more or less on obsolete English patterns, witness H. Lanz, of Mannheim, who is one of the most enterprising and pushing manufacturers exhibiting. In this branch of the trade, therefore, as in the drills, English makers ought still to hold their own on the Continent.

Reapers and Mowers.

The United States of America.

In considering this sub-division of the agricultural machinery exhibited at Vienna, we propose to deviate somewhat from the geographical order we have previously adopted, and to commence with a consideration of the exhibits which showed the most striking originality of detail, and which have been more or less freely copied by all European manufacturers.

The United States, then, exhibited undoubtedly the best and most instructive collection of reaping and mowing machines in the Exhibition, and this arose, to a great extent, from the fact that in the east of Europe, American manufacturers have established business on so extensive a scale that English makers are unable to compete with them. All the great manufacturers in the United States were, therefore, fully represented, not as strangers, but as the recognised suppliers of the ever-increasing demand in the agricultural districts of the south of Russia, Austria, Hungary, &c. It is not surprising that, in reapers and mowers, the United States should enjoy so great a popularity. As much ingenuity and skill have probably been displayed there in the improvement of these implements, as in the perfection of sewing machines, and there is scarcely a crooked piece of iron in any one of the reapers that were on view at Vienna that is not the subject of at least one patent. The American implements have, moreover, special advantages which recommend them strongly to the purchasers where the European trade is largest. The corn-growing districts of Hungary and Russia correspond closely to the great grain-producing areas of the United States, so that the machines perfected for the latter conditions, are, of course, well suited to the former. Another point much neglected by all but American makers of these implements is the comfort of the men in attendance. At best, English reapers have a seat supported on a long bracket, on one side of the machine, out of the way of the revolving rakes, but so placed that the horses have to be driven in an inconvenient position. This is not seen in American machines of any standard type; comfort to the driver in charge of

the implement being a leading and very necessary as well as economical consideration. In the American machines the rakes do not revolve in a fixed plane, but as they rise from the back of the platform are gathered up into a nearly vertical position, so as to be out of the way of the driver, who can, therefore, sit fairly behind his horses. Leaving aside for the moment the consideration of comparative ingenuity displayed by American and other makers of reaping machines, we are forcibly brought to the conclusion that the workmanship in the former is more suitable, and in many respects far better than in the latter. For example the same peculiar skill which is shown in the construction of American carriage wheels is seen in the woodwork of the reapers, especially in the rakes and platforms, the combination of strength and lightness in which is remarkable. Lightness in every part, indeed, is a special characteristic of these implements, as compared with English and Continental machines of the same class, and this speciality, which, perhaps, was first forced upon American builders to suit the horses of their home farmers, is equally appreciated in Russia and Hungary, where a light draught is all important to conform to the capacity of the average horses. The special object of the American builders appears to be, to combine strength and efficiency with lightness and cheapness of construction, at the expense, no doubt, to a certain extent, of durability; but apparently it suits the American farmer to purchase machines at a moderate price that may wear out in a few years, but not before they have paid for themselves many times over, and which if they were more durable would probably become comparatively obsolete long before they were past service. It would seem as though the American makers had succeeded in making their European purchasers adopt the same ideas.

Turning now to a somewhat detailed consideration of the reaping and mowing implements that were exhibited by American makers, the stand of one of the leading firms, the Walter A. Wood factory, of Hoosick Falls, New York, at the eastern end of the Agricultural Hall, first claims attention. There were exhibited here one "New Champion," and one chain rake reaper, with two mowers. The wood factory occupies a leading position in this trade, and has turned out since the business was commenced in 1848, no less than 160,648 implements, of which the "New Champion" is now a favourite and valuable type. In this machine the motion is given to the cutters in the usual way, but the mode of working the rakes is extremely simple. The accompanying sketch, Fig. 89, will explain the arrangement. Motion is imparted to the pinion, *a*, from the driving wheel of the implement, and actuates the wheel, *b*, which is attached to the bonnet piece, *c*. A fixed cam, *d*, is placed underneath the piece, *c*, and governs the motion of the rakes, of which there are four, pinned to the bonnet piece, *c*, between the projecting lugs made to receive them. The bottom of each rake arm terminates in a roller which presses against the side of the cam. From the sketch it will be noticed that a path for the rollers is made around the bottom edge of the cam, and that this gradually changes from being nearly vertical, and corresponding to the highest position of the cam, to the opposite side, where the path dies off from the side, and turns beneath the cam. The rakes are coupled together in pairs, as shown by the rod, *e*, and as the ends of these rods are attached to slotted links at the sides of the arms, the distance between them being regulated by shifting the position of the links, the rakes may thus be worked in pairs if desired, instead of all four being employed, the shortening of the distance between them having, of course, the effect of throwing up the pair thus adjusted clear of the platform, when it is wished to regulate the size of the sheaves. An ingenious adjustment is employed to keep the rakes always parallel with the cutters when they reach the platform. This reaper has a very efficient steering arrangement under the control of the driver, and the height of the platform, the cutters, &c., can be adjusted at will. The same makers exhibited also a chain rake reaper of ingenious construction, but certainly neither so practical nor efficient an implement as the one just described, although it is stated that they are largely used in the States. Fig. 90 gives an indication of the arrangement. Gearing, consisting of one wheel fixed on the driving shaft of the implement, an intermediate wheel, and a third attached o the outer end of the spindle, *a*, complete the means for driving the chain

The table is of the form shown in the sketch, *b*, and at each corner, *c*, is a pin which forms the centre of a small pulley over which passes the chain, *d*. This chain is driven round constantly by means of gearing worked from the spindle, *a*. The rake is of the form shown; it is hinged to a part of the framework of the implement at *e*, and the other end of the rake is attached to the chain at *f*, there being an intermediate hinge, as shown. The chain constantly moving, carries with it the rake, which sweeps the whole area of the table at each complete circuit. This arrangement, though effective as far as it goes, is open to the objection that it does not afford a means of regulating the size of the sheaf thrown off, as in the other implement by Mr. Wood, just noticed; it appears also more liable to get out of order, and unsuitable except for crops in good condition. This implement is furnished with a four-armed flyer, driven in the ordinary way by a pitch chain off the main shaft.

In the next stand, Messrs. Aultman, Millar and Co., of Akron, Ohio, one of the firm of manufacturers of the Buckeye machines, exhibited their combined reaper and mower, two mowers, and a reaper fitted with Millar's revolving table, which implement has, at least, novelty to recommend it. The motion is taken off a bevel wheel on the axle of the implement, by means of a pinion, to a spur wheel quite at the rear of the machine, which drives in its turn a small pinion, the spindle of which passes from the back to the front, and drives the cutters. A second pinion, taking motion from the same bevel wheel on the main shaft, actuates the revolving table which forms the special characteristic of this reaper, and which will be understood from the sketch (Fig. 91). On the platform, *a*, is mounted horizontally an iron disc, *b*, to which is attached a vertical board with three teeth, forming the rake. The table is caused to revolve by suitable gearing driven by the connecting rod, *d*, which has two universal joints in it. The operation of the machine is very simple. On advancing into the crop, the stalks, cut by the cutters in the usual manner, are swept on to the platform by the rake as it revolves with the table, *a*. The size of the sheaves gathered can, to a certain extent, be regulated by the driver, who, by stopping the motion of the table, may allow the grain to accumulate on the platform as he desires. It will be seen that the implement, however, possesses no means of bringing laid crops to the knives, the function of the rake being simply to deal with what is brought up to the cutters. The means for driving the table are moreover open to objection, and the connecting rod with the universal joints lies very close to the ground, so that it of necessity must become impeded by the straw that wraps around it.

Adjoining Messrs. Aultman, Millar, and Co.'s exhibits were those sent by the Johnstone Harvester Company, of Brockport, New York, and who showed one reaper, one combined machine, and one mower. The type of machine manufactured by this firm has many excellent features, the combination of which, together with the good workmanship, tend to make the Johnston implements the leading favourites in Russia, where they are sold in large numbers. The chief features of the implement are an excellent variety of the Johnston rake and the arrangement of the driving gear, which is well elevated, and horizontal instead of vertical. In common with many of the better class of implements, it possesses easy means of adjusting the position of the rakes with reference to the cutter, of regulating the height of the platform, and of tilting the implement at will.

The chief features of the Johnston rake are a switch in the roller cam and appropriate mechanism for throwing open this switch when it is desired to alter the curve of the roller path and lift one of the rakes clear from the platform in order to regulate the size of the sheaf. When all the rakes are permitted to sweep the platforms the cam switch is kept shut and the rollers traverse the outside of the switch, but when one or any greater number of the rakes are to be thrown up the switch is opened at the proper moment, either by hand or by suitable mechanism, and the roller enters its new path. In the original form of the Johnston switch the latter had to be closed by hand, and it was only after a considerable period that the idea occurred to another inventor, and formed the subject of a second patent on

this small piece of iron, to finish the cam with a tail-piece, inclined inward, and of such a form that it should project over the roller path, and be struck by the roller in its onward movement, the blow closing the switch and completing the path for the next rake. In the Johnston Harvester Company's implement the motion of the switch is made automatic in the following manner: Upon the vertical shaft, carrying at the upper end the cap upon which are hinged the ends of the rake arms, is mounted a wheel, to which a vertical movement can be given by means of a lever actuated by the driver from his seat. On raising the wheel it is thrown out of gear with a second toothed wheel running free on a short spindle. It will be seen by referring to the accompanying sketch, Fig. 92, that the wheel, *a*, on the vertical shaft is divided into five parts, corresponding to the number of rakes used in the implement, and that the lose wheel, *b*, has a line marked upon it. Care must be taken in putting on this wheel that the tooth marked thus enters one of the spaces marked in the other wheel, in order that the opening of the gate or switch may be effected at the proper moment. Upon the wheel, *b*, is a curved inclined path, *c*, concentric with the wheel. Several of these wheels, of different sizes, are supplied with each implement, and regulate the number of rakes which are to be thrown up or made to sweep the platform. When it is desired to increase the number thrown up a smaller change wheel is introduced, and thus it will be seen that the action of the rakes is entirely under the control of the farmer, who adjusts the implement before entering the field. Resting on the top of the inclined curved path of the wheel *b* is a small horizontal latch, which is coupled by a lever to a pin on which the switch of the cam turns; a strong spring always tends to keep this latter open, but the impulse is resisted by the pressure of the latch against the inclined path. When, however, the wheel *b* has been driven so far round that the incline has cleared the underside of the latch, an event which occurs just at the moment when the roller of the rake arm has to enter the inner curve of the cam, the latch is thrown back by the spring, the switch opens, and the roller passes, but, going forward, it immediately strikes the tail of the switch, and the blow compressing the spring forces the latch back again over the incline on the wheel *b*, and so restores the arrangement to its normal position.

A neat mode of securing the hinge pins of the rake arms is seen in this implement. The ends of each pin abut against the adjacent ones, so that they lock each other; and the joint is made without any fastenings whatever, excepting that one end of the fifth pin is secured by a set screw against which it rests. The whole of the gearing by which the rakes and cutters are driven is arranged, as we have said, horizontally, with the exception of course of the bevelled spur wheel attached to the driving wheel of the implement. The crank driving the cutter bar is vertical, and runs in upper and lower bearings.

The mowers of the same company are well designed and carefully made implements, though probably they are a shade inferior to the Wood mower. One feature about them may be noticed. The gearing is actuated by the driving wheel through an internal ratchet wheel and four pawls, which drive the implement in its forward motion, but, run loose in backing, the pawls may also be thrown out of gear by a hand lever, and the mower run in each direction on free wheels.

Messrs. Warder, Mitchell, and Co., of Springfield, Ohio, exhibited an excellent "Champion" reaping machine, which made a good show amongst the highly finished implements in this Hall, although it is an ordinary machine taken out of stock; on the other hand, the mower shown by the same firm is highly finished.

These Champion machines enjoy a high reputation in the United States, and the exhibitors have three works in Springfield, each of which find occupation for 300 men. The Johnston rake with four arms is employed, with an automatic arrangement for throwing open the switch, different to that we have described as in use on the Johnston harvester; the switch is moreover under the control of the driver who, by means of a chain, can open or close it at will. The sketch, Fig. 93, shows the general arrangement of the rake, and it will be seen that it is driven not by gearing but a chain. The

arrangement for tilting is simple, consisting of a lever beside the driver, from the end of which a chain passes over a quadrant and is fastened to the platform. Figs. 94, 95, show a neat mode of taking up the wear in the head of the connecting rod, which works the cutter bar. On the underside of the bar, and at its extremity, is a cone which fits in a corresponding tapered hole in the end of the cutter bar; a spring placed on the top of the connecting rod engages the teeth of a ratchet nut, which secures the pin passing through the cutter bar and the cone at the end of the connecting rod, and securing them together. It will be seen that any wear can be taken up by turning the nut, which is kept in place by the spring.

The Excelsior machine, which was exhibited by the J. F. Seiberling Company, of Akron, Ohio, is peculiar in having a delivery directly behind the platform instead of at the side, so that when working it must be followed up by labourers to bind the sheaves. The grain is received upon a table which can be tilted at the will of the driver, and the sheaf, made of any desired size, thrown on the ground. This delivery in the path of the machine is open to many objections, and the implement, taken as a whole, does not compare favourably with the other exhibits which we have described. One combined reaper and two mowers were exhibited by Adriance, Platt, and Co., of New York. It is this firm that purchased the Buckeye patent rights in 1857 for the Eastern States, Messrs. Aultman and Millar having secured for the Western States similar privileges in that year for the same machine, which had been brought into notice at the agricultural trial held in Syracuse, New York, in 1857. These Buckeye implements are well arranged, the frames made light and strong, and the connexions between the machine and the platform are ingenious. The wheels can be made to run either fast or loose on the shaft, so that when not in actual operation, there is no unnecessary wear on the working parts of the machine. In the combined machines, the platform, detached from the body of the implement can be trailed behind, a small extra wheel being provided. Fig. 96 shows the mode adopted for opening the switch of the cam (a Johnston rake is employed). It is very simple, consisting merely of a projecting finger, *a*, connected to the link, *b*, and to the pin on which the switch turns. When this finger is pressed the switch is thrown open, and this is effected either by the driver, for whom a cord connexion, *d*, is provided, or by lowering the radial pieces, *c*, *c*, on the rake arms, in order that they may strike the finger, and open the switch in passing round. Ingenious as this arrangement is, the facilities it offers for regulating the size of the sheaves is limited, and in comparison with the Johnston harvester—where the rakes can be thrown up in any desired combination, regulated by the change wheels already described—it is imperfect.

The Burdick reaper and the Kirby combined mower and reaper were shown by D. M. Osborn, of Auburn, New York. The rake is similar to the Johnston, but the arms are thrown up by lifting a part of the cam which is hinged and thus altering the angle and direction of its path. This is done by suitably arranged levers worked by the driver. The whole of the mechanism of this implement has the disadvantage of being very near the ground, and although an ingenious arrangement, the rake does not compare with the Johnston. In the combined machines made by this company, only one large wheel is employed instead of two, a small additional one being added when the implement is used as a reaper.

Two more machines in this department remain to be noticed, the McCormick, and a complicated arrangement, called the Marsh Harvester, by L. Steward and Co., Plano, Illinois. Of the former little need be said; it is of the ordinary type, well known everywhere, and capable of good work, but not so efficient as the more modern implements around. The latter receives the corn as it is cut, on an endless platform, which constantly revolves and leads the grain to one side, where it is received by a series of endless rubber bands, which rise almost at right angles to the platform and pull around a series of lower and upper rollers. On the outer side of the implement is attached a table upon which the grain is delivered. The workmanship of this reaper, like its design, is inferior to the others which we have noticed.

ENGLAND.

In the English section of agricultural machinery were plenty of reapers, all of standard English designs, contributed by the leading makers. Messrs. Hornsby and Sons, of Grantham, Samuelson and Co., Messrs. J. and F. Howard, of Bedford, all exhibited liberally, reapers and mowers, which are so well known as to need no description. Messrs. Burgess and Key had a McCormick, the pattern of which has been anglicised, and Mr. A. C. Bamlett, of Thirsk, sent a reaper, extremely heavy in design and rough in workmanship. The solidity of the English implements, after an inspection of those in the United States section, is very striking, and though no other maker went so far as Mr. Bamlett, who employed 18 bolts to attach each of his rakes to its respective arm, there appears to be an excess of material, and consequent weight in all the English reaping and mowing implements. That the Americans owe their success at home and abroad, in a great measure, to the lightness of their machines, there is no doubt, and English makers can scarcely hope to compete with them in the Continental fields they have now made almost their own, with the heavy, though perhaps more durable, implements they bring into the market. In one point of design, as we have already remarked especially, the English makers are undoubtedly inferior, namely, the accommodation they provide for the drivers of the reapers—an important point, and one which the Americans have carefully studied.

FRANCE.

In the French department reapers and mowers were represented by MM. Albaret and Cie., of Liancourt-Ratigny (Oise), whose reaper was a most formidable instrument. This maker boldly overcomes the difficulty of providing a seat for the driver, by mounting him near the end of the shaft out of reach of the sweep of the rakes, which are mounted rigidly on an inclined shaft. The machine is thus of a great total length, and awkward of management, the driver is in an uncomfortable position, and has no means of tilting the reaper, although he can throw it in and out of gear with his foot.

MISCELLANEOUS.

In the other departments the reapers and mowers were, for the most part, so-called improvements of English patterns. The Aultman and Millar Buckeye machine was exhibited by the agents of the company Messrs. Schubert and Hesse, of Dresden. Mr. Hopherr, of Vienna, show an "improved" copy of Samuelson's reaper, but with no seat; he had also some mowers. Messrs. Strobl and Baris, of Buda-Pesth, exhibited a reaper with no special peculiarity worth noting; the same remark applies to the three implements shown by Messrs. E. Buxbaum, of Augsburg, and Messrs. N. Jeprau and Son, of Ilsenburg, the latter of whom sent a heavy imitation of Samuelson, with a seat for the driver set necessarily in a very inconvenient place.

Mr. Hanko Neucoschuetz, of Dresden, took the American Burdick for his model, and exhibited one reaper and one mower. The design, however, is not so light, nor does the work appear so good, as in the original design. Messrs. Klemm Brothers, of Eckernforde, sent a reaper with two rakes and four flyers, coupled in pairs, and which revolve around a cam, but without rollers. The motion for working the cutters is taken off a bevel wheel on the driving shaft by suitable gearing, and the rakes are driven by a pitched chain.

We believe that this completes the list of reapers and mowers, though perhaps we may have omitted to mention a few unimportant exhibits. We trust we have said sufficient to show that in this special branch of industry the American manufacturers have surpassed those of any other country—at least in meeting the requirements of those districts where they command the trade—and that English makers will do well to adopt many important details from their designs. On the other hand, there is evident, in the American implements, a tendency to excess of ingenuity, which often appears to be exercised rather for the purpose of evading an existing patent than for the sake of efficiency. As regards other nations the less said the better. The French

exhibit evinced a want of acquaintance with some of the most important principles of mechanical harvestry, and the German and Austrian makers showed a lamentable want of originality, resulting in the wholesale copying of foreign makers, whilst at the same time they introduced many modifications which are the reverse of improvements.

Thrashing Machines.

Thrashing machines were very numerously exhibited at the Vienna Exhibition, all the chief English makers having sent their latest patterns of these implements, while at the same time, foreign exhibits of this class were in considerable force. Of these latter we may make the preliminary remark, that the greater part of the foreign exhibits, while being somewhat primitive, were at the same time highly efficient implements, designed evidently with a view to the requirements of the small farmer.

The absence of real novelty, however, except in detail, was a striking point that suggested itself, after an inspection of the different implements. Too much of novelty was doubtless expected from this department, and so little were these expectations fulfilled, that the collection of Messrs. Ransomes, Sims, and Head, of Ipswich, attracted unusual interest.

This firm has certainly gone in front of many others following the same manufacture, probably because they have realised more fully than any other the fact that under different conditions of climate, labour, methods of cultivation, and of customs, requirements are widely different, and that, for example, the type of thrashing machines best liked by English farmers, would not be suitable for Spanish or Italian wants, any more than the careful straw-saving implements sought after in France, would find a market in the wide corn-growing plains of Russia, where speed of production is everything, and the straw becomes only a cause of anxiety on account of its bulk and uselessness, The fact is that many British manufacturers of agricultural implements cling to the belief that what is suitable to special requirements of the circumstances which have come within the somewhat contracted area of their personal experience must be good for all the world, and that if foreign purchasers conceive that the varying circumstances of climate or cultivation produce a different condition of things, they do not consider that these differences are of sufficient importance to warrant a change of design, or any alteration in the construction of their implements. There can be little doubt that it is this indifference, a want of power to adapt machinery to varying circumstances, that has lost English makers the great reaping machine trade of Russia, and has given it over to the more quick-seeing Americans.

That Messrs. Ransomes, Sims, and Head have, to a great extent, broken through these bonds of conservatism, have carefully examined the requirements of the different countries where the demand for agricultural implements is greatest, and have endeavoured, by constructing various types of machines, to meet all the requirements of different classes, is as much to their credit as it certainly must be to their profit, and this speciality entitles them to the first place in this notice of thrashing machines at the Vienna Exhibition.

Take first their great machine, Figs. 97, 98, Plate 237, which will turn out from 1,000 to 1,200 bushels of wheat a day. Every detail of it has been carefully studied, and all the salient points show originality. It is specially designed for the great wheat-growing fields in the south of Russia, where speed of delivery is all important, and crops have to be converted into money in the shortest possible time. Every part about this machine is made extremely strong, the spindles have grown into shafts, the framework is massive, and no weight has been spared in any part, for labour is cheap, and if the draught of the machine is heavy in moving it from place to place, a few more oxen make no difference, while if any part of the machine became disabled the delay would be always serious, and sometimes irretrievable. Another speciality. When at work these machines are always crowded with workpeople, often from 30 to 40 men and women are about the implement, and upon the platform. The latter is, there-

fore, made very large, and a hinged fence is placed around the feeding hopper to prevent anyone from falling in, an accident which has often occurred, and, of course, is generally attended with serious results.

The sheaves, fed into the hopper as fast as they can be delivered, for a speed of from 1,000 to 1,200 revolutions is the working rate, pass upon the drum, which is made very heavy to suit it better for thrashing dirty crops, and is fitted with the usual twisted beaters, and thence between it and the concave, which is made of malleable cast-iron gratings, on to a wrought-iron frame, the gratings being placed in sections and secured by circular bolts, in such a way that they can be easily removed. After being forced through the narrow space between the drum and the concave, and thus being relieved of the greater part of the grain, the sheaves pass out upon the first straw shaker, which extends from the concave with a considerable inclination upwards to about midway of the machine, where it falls upon a second, and similarly inclined series of shakers, placed at a lower level, and by these is carried to the delivery at the front end of the thrasher. The shakers used are known as Brismead's patent, and consist of a number of short curved blades set on an endless band, a series of these being placed side by side, so as to occupy the whole width of the machine, and as the set of the blades is different in each row, the straw is seized by a very large number of points as it leaves the concave, and so agitated during its transit on the shakers that the grain still held in the straw is effectually removed. The object of having two rows of shakers in this machine is because it is driven at a very high speed, and it was desirable, indeed necessary, to give as large an area as possible to the straw, in order to extract the remaining grain, during the short time that elapses between the straw leaving the shakers, and being delivered. The loose wheat thus shaken out passes between the spaces in the shakers, on to close trays, parallel to and immediately below them, and thence falls upon the large top riddle, or "jog-shoe," extending for about two-thirds the length of the machine. This riddle, which is suspended in the usual manner, on the outside of the frame by woven wire and hemp straps, is agitated by a crank-shaft in the front of the machine, but is not exposed to any action of the blast. The bottom of this riddle is perforated with circular holes, through which the grain, chaff, &c., fall to the lower riddle, the larger bodies being shaken off the front edge of the top one. The lower riddle is driven off the same crank as the upper one, exposed to the blast from the fan, and the chaff and other impurities are blown off, falling in the front of the machine, and mixing with the larger waste shaken off the upper jog-shoe. From the lower riddle the grain falls into the elevator box; the elevator, which is vertical and inclosed in a box outside the frame, lifts it nearly to the top of the machine, and to a point just behind the drum and concave. From the elevator it may be delivered direct into sacks, but this is only done when the grain is very smutty, and careful hand winnowing is necessary. With average crops, the grain passes from the elevator into the barley awner and chob cleaner, which consists of a conical drum, the inside of which is serrated; and the grain being driven against these serrations is effectually cleaned. According to the nature of the grain different serrations are required, and different classes of cleaners are supplied with each machine. From the cleaner the grain falls on an inclined plate, and sliding down this passes upon a sieve inclined in the opposite direction; the underside of this sieve is exposed to the action of a blast, which also strikes through the grain, as it pours in a cataract from the sieve into the hopper. This hopper is divided by a vertical plate, placed below the edge of the sieve, so that the cataract of grain would only just fall on one side if there was no blast, but the action of the fan is sufficient to throw out the dirt, light grain, chaff, &c. upon the other side of the plate, and so effect a perfect division of the grain. From the hopper the grain is loaded into sacks. This simple mode of separation is found for these machines to be more useful than the revolving sieves, by which the grain may be divided into several different qualities. It generally happens, however, that with wheat intended for exportation the wheat is mixed again before being shipped, so that the previous separation is useless. We should mention that the arrangement of discharging the chaff at the front end of the machine, where it mixes

at once with the ears, broken, straw, &c., is a special feature. In England it is considered necessary always to keep the chaff separate; in Russia, on the contrary, farmers prefer to have the whole débris mixed together as fodder.

The second and third thrashing machines that were exhibited by this firm are of a different class, and are intended for districts where quick work is not so great an object as perfect thrashing. The first machine has a 4 ft. 6 in., and the second a 4 ft. drum. Both drum and concave are similar to those just described in the large machine. The straw shakers are also similar but are single, not double and less inclined; they are provided also with what is technically called a "puddler," that is to say, a transverse bar, which goes across the machine, just above the shakers, armed with forks, motion being given to the apparatus by connecting rods from a crank-shaft. The object of the "puddler" is to distribute the straw thoroughly over the shakers. The general arrangement of riddles, blast, &c., is the same as in ordinary first-class machines, the most novel feature being that the chaff can be delivered at the front, instead of at the back of the machine, as usual. In the larger thrasher of the two, however, the chaff finds its exit from behind, but a new mode is adopted of removing it. A fan is placed at the back of the bottom riddle, and is in connexion with a rectangular pipe, the direction and inclination of which can be regulated at will. The upper end of the pipe is split into two smaller square pipes forming mouth-pieces, and the fan blows the chaff through the pipe as fast as it is formed, and delivers it at the mouth-piece, where it may either be discharged into a cart, or taken into sacks.

The two other thrashing machines which were exhibited by Messrs. Ransomes, Sims, and Head, are entirely specialities, and are intended only for use in hot countries where the straw is extremely hard, and quite unfit for consumption by cattle, without having been previously bruised and softened, and where no ordinary cutting apparatus serves to prepare such straw, which, when clean cut into short lengths, cannot be eaten without promoting serious internal diseases.

The first of these machines, which is especially adapted for use in Spain, Italy, Turkey, Chili and Mexico, can, however, when it is desired to deliver straight straw, be worked as an ordinary thrashing machine, the crushing rollers in this case being covered up, and the straw delivered in the usual way. The constructive arrangement of this machine resembles that of the ordinary double-blast thrasher, and the drums are mounted at the front end of the machine. There are two of these drums, both made of sheet iron, with cast-iron heads; they are very carefully balanced, and their spindles run in long bearings formed in cast-iron standard brackets which are attached to the frame. Both drums are driven off the main shaft of the machine, but are run at somewhat different speeds, the upper one making 1000 revolutions, and the bottom one 900 revolutions per minute. In the top drum there are three spiral rows of knives, which are attached to the inside of the drum, and project from the outer face. These knives are straight and slightly tapering, with the edges sharpened on all three sides; they are grouped in pairs, each blade of which is only so far apart as to permit a single blade of similar construction to pass between them. These single blades are attached to the concave in connexion with which this drum works, like the main drum at the back of the machine. The straw passing off the shakers between these knives is effectually cut up into pieces of irregular size and form. Passing then upon the lower drum, it is still further bruised by the second set of knives; these latter, of which there are four rows attached in spirals around the bottom, are single, and should be called rather teeth than knives; they run between a double set of similar teeth fixed in the concave, there effectually complete the bruising operation, and leave the straw in the desired condition. Connected with this machine, is an independent apparatus for raising the chopped straw as it leaves the drum, and depositing it away from the machine. This consists of an elevator on a separate carriage, having at the lowest point a fan, driven by the engine, and which communicates on the one side with the bruised straw delivery, and on the other with a long wrought-iron tube, the length or angle of which may be varied at will. The tube is about 12 in. in diameter, and each length is provided with a cast-iron bayonet joint as a means of attachment. The tube

is connected at the bottom by a joint to the fan casing, and at the front end of the frame are a pair of light jibs, to which it is secured by a chain that passes over a winch also mounted on the carriage, and by which the elevation of the discharge of the tube is regulated. The action of the fan drives the bruised straw in a continuous stream through the tube, and is at once an efficient and economical method of getting it away from the machine. The tubes of this elevator, which are made in about 7 ft. lengths, are placed in saddles provided upon the carriage for the purpose. (See Figs. 99, 100, 105.)

The experience gained with the working of this machine showed a rather curious and suggestive fact, namely, that the action of the cutting and bruising drums did not in any way injure the wheat, and the idea then naturally suggested itself that a simple and more direct-acting machine could be made, which should cut and bruise the straw, and at the same operation, extract the grain. Of course one condition of such a machine would be that it could not thrash straight straw.

The result of this suggestion is the fifth and last thrashing machine that was shown by Messrs. Ransomes, Sims, and Head. It is a short, light implement, with a cutting cylinder and concave, arranged similar to the one just described, occupying the position taken by the beating drum in ordinary machines. The grain to be thrashed is fed into the drum from an inclined plane, and after having been exposed to the action of the first, it is passed forward to the second drum The teeth in this latter are also similar to those in the corresponding drum of the last machine, but the relative position of the two cylinders is different, they being placed horizontally instead of vertically. The grain, chopped straw, chaff, &c., are all discharged from the second roller upon a distributing plate, and thence to the first riddle, which extends for nearly two-thirds the length of the machine, and consists of a series of stepped plates about 17 in. broad, and perforated with circular holes. The grain, chaff, &c., fall through holes in this riddle upon a plate below, which inclines both ways towards pockets at the side of the machine, which lead it upon the ordinary riddles placed below. From the first stepped riddle the chopped and bruised straw falls upon a second similar one, and travels forward towards the front end of the machine, dropping the grain still contained in it, until by the time it has reached the end,—where there is a third roller for further bruising the straw if desired,—all the grain has been separated, and has fallen in the system of riddles beneath, where it is exposed to the action of the blast, and is treated as in an ordinary machine. (See Fig. 106.)

Messrs. Clayton and Shuttleworth, of Lincoln, exhibited five thrashing machines, which, without presenting any special novelty of detail, are first-class examples of their ordinary implements. They all of them are built with trussed side frames, which stiffen the machines, and enable them to withstand the rough usage and exposure to which they are submitted when at work. They are also fitted with a screw brake to the rear wheels. The arrangement is simple, and one easily repaired. Messrs. Clayton and Shuttleworth employ exclusively for the beaters of their drums, rolled steel plates, as being tougher than any other material. Cast-steel plates are liable to break when stones are fed into the drum with the straw, and many accidents have occurred from this cause. The feed hopper is protected by a hinged board, which is thrown over when the machine is running, but not thrashing. A similar detail is to be found in Messrs. Ransome, Sims, and Head's thrashers. It has been found absolutely necessary to introduce it in the districts where it is the custom to crowd the machine with workmen and women.

In one of the machines exhibited Wilder's automatic feed is adopted, consisting of five oscillating boards similar to the shakers, and inclined downwards towards the drum; these boards are worked off a five-throw crank-shaft, precisely as the shakers are, and have attached to the top a series of ridges for helping the straw down towards the beaters. Immediately above the entrance to the drum is a transverse bar carrying a number of tines, to which a reciprocating motion is given in order to bring the straw forward at each stroke. The range of movement can be adjusted by altering the throw of the crank actuating the bar, and the height of the latter may be varied at will as it slides up and down in a slot, and is fastened by a bolt. The lower the bar is set the

deeper the tines penetrate the straw, whilst when it is raised the tines, having a slighter hold, feed less into the machine.

The mode in which the shakers are operated is worth noticing. A transverse shaft with as many cranks as there are boards gives motion to the shakers, and these are supported in pairs by rocking shafts and arms at the front and rear of the machine. In the 5-ft. machine, where five shaker boards are employed, three are attached to the rocking arms at the back of the machine, and the other two are similarly secured near the front end. This arrangement secures a greater range of motion, and clears the straw of the wheat more thoroughly than the ordinary shaker. The chaff is either delivered direct on to the ground, or, as in one of the machines exhibited, it is cleared from dust by a fan, the dust passing out through an inclined sieve, while the seeds, &c., drop upon the ground from below, and the chaff passes into an elevator at the side of the machine, whence it is lifted to a discharge and passed into sacks. This arrangement, which is to be seen on several of the thrashing machines exhibited by other makers, does not find favour in any but the more advanced agricultural districts, the simpler mode of discharging it upon the ground being generally used.

Two classes of grain elevators are found in these machines, one the ordinary endless band with cups, which raise the wheat from the receiver, and the other —Bruckshaw and Underhill's—which projects the grain up to the screens in a solid column by means of a centrifugal fan in the receiver. This latter arrangement, suitable in England, is not found to answer well in hot dry countries where the grain is brittle and is brought to the thrashing machine direct from the field. The force with which it is projected by the elevator breaks up such grain and damages it considerably.

The barley awners attached to these machines are threefold in their action. They are contained in a horizontal cylindrical casing, divided into three compartments, which may either be placed in through communication or be shut off into single chambers. The first portion contains a simple screw, which feeds the grain as it comes from the elevator into the next compartment, or if the partition be closed it passes down upon the sieves and into the screen. This second compartment is provided with a series of blades set spirally on the shaft running through the centre of the cylindrical casing, and serves the purpose of cutting off the small projecting pieces of husk, &c., from the grain. The third consists of a series of a bars attached at the ends to two discs mounted on a central shaft. These discs are of such a diameter as nearly to touch the inside of the cylinder, which in this division is serrated on the inner side. The bars, which are arranged spirally, may be adjusted in regard to their distance from the cylinder, so as to leave more or less space for the grain. The arrangement is, in fact, like that of a drum and concave, and is used for detaching the small grains that may still lie in the extreme ends of the ears which may not have been removed by the shakers or sieves. Passing through one or all of these cleaning operations, the grain falls on the small sieves, and thence into the revolving screen. Messrs. Clayton and Shuttleworth employ two kinds, the Penney and the Rainforth screens. In both of these the distance between the meshes can be adjusted by means of a nut on the end of the shaft on which they run. In the former case the screen consists of a suitable circular frame, around which a continuous wire is wound spirally, so as to form a cylindrical screen or cage. By altering the position of the sliding ring of the screen, that is, by increasing or diminishing its distance from the opposite or fixed ring, the pitch of the spiral wire is altered, and the width of the spaces is increased or diminished.

In the Rainforth screen a somewhat similar frame is used, but instead of the spiral wire a woven mesh is employed; and by extending or compressing the screen the size of the holes in the mesh is regulated.

The grain is delivered from the screen into hoppers with mouth-pieces, whence it is run into sacks, the division into different qualities being regulated by the position in which the grain issues from the screen, whilst the chaff brought over to this stage also falls through another part of the screen, and is delivered by its proper mouth-piece.

In connexion with these machines we may notice a neat arrangement of barrow for saving the labour of one man in lifting a full sack upon the back of another. It is a vertical tip barrow, the frame of which—upon which the sack lies—can be raised to any convenient height, so that one man can take the sack upon it from the thrasher, and, placing it in a vertical position, can raise it to the level he desires, and take it on his shoulder without any auxiliary aid.

The straw, hay, and sheaf elevators exhibited by Messrs. Clayton and Shuttleworth also form a part of their thrashing machine plant. The former of these consists of a long trough mounted on a carriage, and capable of being adjusted to any angle by means of a quadrant rack, one of which is fixed to each side of the trough, but when the height required exceeds the length of these quadrants a supplementary pair, carried on a carriage, can be added. Two endless chains run over suitable wheels at the upper and lower ends of the trough, and carry between them at fixed intervals, transverse bars armed with tines. The row of driving tines point downward to the bottom of the trough, but have a considerable clearance. A large open hopper at the lower end of the machine receives the straw from the shakers of the thrashing machine, and the elevators may be driven either from thrasher or by an independent pony gear.

The stacking machine for raising loose straw, hay, sheaves, or bundles, is similar in general design, but the endless chain is arranged so that the tines sweep along the floor of the trough with their points upwards. Both these machines are adapted to work up to heights varying from 18 to 24 ft.

All the principal English manufacturers of agricultural machinery sent thrashing machines to the Vienna Exhibition, but there were few specialities and fewer novelties in construction to be recorded. Messrs. Robey and Company, of Lincoln, Messrs. R. Hornsby and Sons, of Grantham, Garrett and Sons, of Leiston, the Reading Iron Works, and Nalder and Nalder, of Wantage, were amongst the chief of those we may name without devoting much space to any notice of their machines, most of them being of the ordinary types of the different makers, and all excellent in workmanship. Figs. 107 and 108 show the arrangement of a compact and well-designed but extremely ill-made horse power thrashing machine exhibited by Messrs. S. Lewin and Poole.

We may add a few words here about the machines exhibited by Messrs. Robey and Co., of Lincoln, combining all the best details of which they have made a speciality. One of the most important of these is the adoption of an iron framing, which differs from the composite framing employed by some other makers exhibiting in several important points. The side frames of Messrs. Robey's machine are formed of angle iron, which follows the contour of the machine, and is connected by vertical, diagonal, and horizontal bracing. The transverse frames are also of angle iron, so that the body of the machine is built up entirely upon an iron skeleton. Considerable experience with these machines has shown that the form adopted is well suited to resist the strain of transport and of actual use. The extra weight involved is very trifling, and though the machines are very rigid, they are at least as well suited for transport as those built entirely of wood. At the same time they are not exposed to the disadvantage under which timber frames always labour, especially in hot dry countries—that of warping and parting at the joints—a contingency which no amount of care in selection of materials and workmanship can prevent, after a few seasons of actual work. Moreover, the iron frames are as easily mended as the timber ones, for there is nothing about them that would be beyond the repairing capacity of a common smith.

We may briefly describe the principal features of the machines exhibited by Messrs. Robey, premising that the workmanship upon them was fully up to the "Exhibition," and beyond a commercial, standard. The top platform is large and spacious, well suited to accommodate the number of workmen who crowd the foreign machines. Rolled iron beaters of the ordinary form are adopted, mounted upon an iron drum, of sufficient size and weight to deal with the maximum amount of straw that can be crowded into it from the feeding hopper. The shakers, four in number in the larger machines, are driven off one shaft, and at the end near the drum are hung to four vibrating

beams. To the two outside beams are attached the rods which move the small upper riddles that receive the grain from the barley awner.

Besides the spindle driving the fans, there are only three through shafts upon these machines—that upon which the drum is mounted, the crank-shaft for working the shoe and riddles, and the one for actuating the shakers. The second of these three, has four cranks and connecting rods, of which the outer pair drive the shoe, and the inner pair the riddles. The corn falling from the drum and shakers, drops upon the shoe, and thence upon the series of riddles provided, finally reaching the lowest level of the machine, which is inclined towards one side, where the junction with the elevator box is made. In passing over the lower riddles the grain is of course exposed to the action of the larger fan, which is mounted on the same shaft as the small one for the second and top series of riddles, a division being made in the casing which is common to them both.

An ordinary cup elevator is employed, which lifts the grain to the top of the machine, and passes it into the barley awner, the first part of which consists of a series of knives mounted on a shaft, and revolving within a plain cylindrical casing, and the second of a small drum carrying revolving bar beater, also in a cylindrical casing. Passing through this apparatus, the grain comes out into the upper riddles, where it is exposed to the blast from the small fan, and ultimately enters the screens, previously dropping the light grain, &c. into a receptacle, whence it is received into bags. Under the screen are different hoppers for the different qualities of grain, with discharge shoots in connexion with each. It may be noted that Messrs. Robey and Co. employ the Rainforth screen in their machines.

Messrs. Marshall and Sons, of Gainsborough, exhibited some thrashing machines, also with iron frames, but of course differently arranged to that of Messrs. Robey. The former firm do not employ angle iron framing, with timber sides, but prefer plate sides, about ¼-inch thick, and stiffened at intervals by transverse iron framing.

The work on the machines that were exhibited by this firm is extremely good, but as we have already said, few details of novelty present themselves. The position of the concave with regard to the drum can be regulated from the outside of the machine by nuts, which, when moved, carry with them an index sliding against a graduated plate, by means of which the concave can be adjusted with accuracy to any desired width, according to the crop passed through the machine.

One of the implements that was shown is provided with a small fan on the same shaft as the main fan, and is employed for elevating the chaff to a box with two spouts, whence it is delivered into bags. These spouts are used alternately, the mouth of one being always kept closed, so that the discharge may be continuous. A third fan is also added to the larger of these machines, for ventilating the small riddles upon which the grain falls from the barley awner.

If desired, the chaff can be delivered direct upon the ground instead of being passed through the chaff elevator.

These exhibitors showed amongst others a thrashing machine, intended by them to take a part in the competitive trials which it was originally contemplated to conduct during the Vienna Exhibition, but which, of course, were not carried out. Figs. 101, 102, 103, and 104, show clearly the construction of the iron framed thrashing machine, made and exhibited by the same firm.

Messrs. Nalder and Nalder's machine was fitted with their beautifully made corn screen, in which the wires are seated in grooves cut in the bars forming the frame. Messrs. E. R. and F. Turner's thrasher had a chaff elevating and sacking apparatus, and is adapted for thrashing rape. The frame of Messrs. Willsher and Co.'s machine was noticeable for the peculiar arrangement of iron bars and straps employed to strengthen and stiffen the frame, an object well secured, as we have already seen, by the trussed side frames adopted by Clayton and Shuttleworth. Messrs. Wallis and Stevens had, among others, a neatly made and compact thrasher driven by horse power, and mounted on a carriage, together with the gear ready for transit. A section of this machine is shown in Fig. 109.

FRANCE.

France was but poorly represented in agricultural exhibits, and thrashing machines formed no exception to this rule. Still two makers contributed to this class, MM. Albaret and Co., of Liancourt (Oise), and M. Del. Ferdinand, of Vierzon (Cher). The former maker had two machines, both well made, but not adapted for delivering at such high rates as the standard English machines. On the other hand, the delivery of the straw uninjured is an object sought for amongst French farmers. In the Albaret machine, the grain, after passing through the upper sieves from the shakers, is received into two hoppers, which lead it into two other series of narrow sieves on each side of the machine, where the action of the blast separates the chaff, and the grain is delivered by side spouts.

In the thrasher of M. Ferdinand the process of separating is not carried so far. The grain is brought on to a sieve the width of the machine, and formed with narrow strips of wood instead of meshes. These strips are arranged like louvre boards, inclined towards the fan, so that the tendency of the blast is to drive the chaff forward, while the grain drops down through the openings between the strips of the sieve, and is delivered by a side spout. Dust and general impurities fall at the outer end of the sieve, and pass out at the opposite side of the machine, while the chaff itself is blown out continuously through the openings at the back.

In the Agricultural Hall devoted to the exhibits of Germany, Austria, Hungary, &c., there were a very large number of thrashing machines, which may be divided into two or three classes.

First, of course, there were the chief makers, Messrs. Clayton and Shuttleworth, of Vienna, Messrs. Garrett and Co., of Buckau, near Magdeburg, and Robey and Co. of Pesth. These, of course, all make machines of their ordinary type, besides smaller and more rudimentary ones for the special requirements of their trade.

Then there were those makers who follow English models. Under this head were included nearly all the exhibitors in this hall. But we hold that there is a difference between adopting a system, as, for example, Mr. Bernhard Eichmann has done that of Marshall, because it suits him, and such a maker as Mr. Hoffher, who exhibited an excellent copy of Ransomes, Sims, and Head's thrashing machine, in which even all the index letters on the different parts were reproduced. This is simply imitating a trade mark. Mr. Vidats, of Pesth, has done the same thing by another leading maker, but then his copy is not nearly so well made as that of Hoffher, and the harm done to the original producer is not so great in one way, although in another sense it is certainly damaging to have clumsy forgeries of a machine produced and sold.

A similar act of piracy was found at the stand of a firm of Italian exhibitors, Messrs. Cosomini and Co., of Grossetto. This was also an exact imitation of Messrs. Ransome and Co's 8-horse single-blast thrashing machine, extremely well made, and having the woodwork varnished, instead of its being painted after the original, as was the case with Hoffher's machine.

Under existing circumstances no one can blame foreign makers for copying English machinery, provided they sell them as copies, but the fact of reproducing the actual letters and marks of a maker of reputation, and by which a machine or its parts are identified between the manufacturer and his customers, is *primâ facie* evidence of a desire on the part of the imitative producer to take advantage not only of the brains and experience of the originator, but of his reputation and business connexions also.

The third class of thrashing machines found in this hall, were more or less primitive, adapted for the use of small farmers, tolerably perfect in their action, comparatively of considerable capacity, and cheap.

AUSTRIA.

It is almost needless to say that machines of primitive type were numerously represented. Messrs. Clayton and Shuttleworth, along with their larger machines, exhibited some of them. And we may take this opportunity of saying that neither in this nor any other part of the Exhibition was better workmanship to be seen, than at Messrs. Clayton and Shuttleworth's Austrian stand. The castings, it is true, were highly finished by hand, but with this exception, there was little or no difference between their exhibited and their ordinary commercial machines. Their hand-worked thrasher contains a drum, the beaters of which are flat bars with corrugated surfaces, and the concave is formed to correspond. It is driven direct off a large toothed spur wheel and a small pinion. The grain is fed into the drum from a large table, and then passes from the drum upon an inclined grid, the straw falling out in front, and the wheat dropping upon the floor. The same firm exhibited, as we have said, two or three steam-power machines, one without a blower, and delivering the grain from the sieves upon the ground. The carrying wheels of these machines are of cast-iron, with wrought-iron tyres shrunk on.

A speciality of Messrs. Clayton and Shuttleworth's exhibits were three machines for preparing maize. The largest of these was in all respects a thrashing machine adapted for its particular work. The feed is a hopper placed above the drum, and at one end of it, and the drum itself is peculiar in being formed of a sheet-iron cylinder studded with several spiral rows of small teeth, which bring the husks of the maize in contact with the concave, which has a smooth surface, and extracts the grain while the husks travel forward, and are expelled through an opening at the other end of the drum casing. The grain thus separated falls upon riddles, where it is exposed to the action of a fan, and thence into the chamber of an elevator, by which it is raised to the point of discharge, and is taken into sacks.

The second of these machines was simply a husker, with a hopper feeding on to a similar drum, through which the grain is passed upon the floor, and the shells are discharged through the opening at the opposite end, the rate of discharge being regulated by a sliding cover over the opening.

Lastly, there was a small hand maize sheller of quite a different type, and of most ingenious arrangement. It is a vertical implement, and the cobs of maize are introduced separately into a circular opening in the top of the table. They fall down vertically within a hollow cone, and come in contact with a rapidly revolving and bulbous shaped beater covered with studs; by the action of this beater the grain is extracted from the shell, and all fall together upon the ground.

MISCELLANEOUS.

We may consider that the small thrasher we have just noticed in Messrs. Clayton and Shuttleworth's exhibits, represented in its best form the most primitive implement of its class met with in the Exhibition. The next form, and more numerously represented, is somewhat similar, with the drum and beater delivering direct upon the floor, but with the addition of shakers, which effect a more complete separation, and moreover, deliver the straw at some little distance from the grain. We may, perhaps, take Mr. Heinrich Lanz, of Mannheim, as the representative exhibitor of this class, although there were several others which approach closely to his excellent workmanship in those simple machines. One novelty introduced by him is the substistution of one broad shaker for the three narrow ones commonly in vogue, and although there is doubtless a more effectual separation with the double or treble shaker, the price of these machines is reduced by the adoption of the single one. These small machines are worked by hand, the first motion being geared sufficiently to get up a high speed of drum. The refinement of detail employed by this maker of running his drum upon centres, instead of in bearings is good, as the friction is thereby reduced, and the drum runs much lighter.

We may here point out the almost universal adoption of the American peg drum and concave, in which sharp pointed pins project from the drum, and

similar ones are bolted to the inside of the concave. A comb, the spaces between which correspond to the form and width of the pins, forms a part of the feeding plate next the drum. This arrangement is to be met with on nearly all the cheap thrashing machines, but it has, we believe, only been introduced very recently. As we have seen, however, Messrs. Clayton and Shuttleworth do not employ it, using instead the better form of drum with corrugated beaters.

The machines of Mr. Lanz had been very closely but very badly copied, so far as workmanship goes, by Mr. Umrath, of Prague. Indeed, there were very few things in the way of bad work which surpassed these same exhibits. Near Lanz's stand was that of Weil, of Frankfort-on-the-Maine, who had a number of similar small machines, which were, however, made partly or wholly of iron—a somewhat doubtful advantage, we should imagine, in these thrashing machines. At all events the work here is excellent, and the machines can be employed either with or without the shakers. Like Lanz, Mr. Weil hangs his drum upon centres, and has a screw adjustment for regulating the width or clearance between the face of the drum and that of the concave. Mr. F. Dehne, of Halberstadt, showed a machine of somewhat more complicated arrangement, and in which the bars of the shakers are of sheet iron, and the frames of wood. The sides of the latter are cut into furrows, with an angle of 45 deg., and the sheet iron strips are placed upon them, so that they present an inclined surface to the grain as it passes along with the straw from the shakers. Beneath these there is an inclined riddle, but no fan, and the grain falls on the floor. The second machine has a very broad feed, and the drum is provided with ordinary rolled grooved beaters. There are neither shakers nor riddles to this machine, and the grain is of course delivered direct upon the floor. Fig. 110 shows a common type of thrashing machine, exhibited by Mr. H. Friedlaender, of Ratibor.

We may compare the former of these with those exhibited by E. Buxbaum, of Augsburg, in which the bars of the shakers are also of sheet iron, but in this case they are ingeniously cut out of a solid plate, and turned up at an angle. In other respects these thrashers of Buxbaum are more complete than that of Dehne's, inasmuch as they are provided with a blower. The grain falls through the shakers upon an endless band, which, having an inward motion, feeds the grain on to the riddles, where it is exposed to the blast in the ordinary way. The grain is delivered at the side of the machine. This same maker had three smaller machines, without any blower, but with, in two cases, an inclined riddle below the shakers; in the other the grain is delivered direct upon the floor.

Messrs. Lilpop, Rau, and Co., of Warsaw, form a firm of some little importance, and whose exhibits we have noticed previously. They had two fixed thrashers, one quite a complete machine, with four beaters, the outer ends of which have each a short length of channel iron bolted beneath them, and serving as guide for four rollers mounted on one shaft, upon which the ends of the shakers rest. This machine is provided with a fan, and has a side delivery for the grain.

Let us remark in passing that in the machines shown by Ladislaus Mencel, of Bialazerkoff, in Russia, the same arrangement of bearing rollers is employed for the shakers, and an Archimedian screw elevator is used for raising the corn, being the only, or almost the only arrangement of the kind in the Exhibition.

The second machine of Lilpop and Co. is without shakers, delivering the straw direct with the grain, and is provided with a drum and ordinary grooved beaters. There is some heavy driving gear on the top of this machine.

We should also notice the thrasher shown by Robey and Co., of Pesth, a machine with no speciality of detail, and of very indifferent finish. On the other hand, that exhibited by Mr. Nicholson, of Pesth, reflects considerable credit upon the makers, from the manner in which the work is executed.

Maurus Glas, of Freising, in Bavaria, had two thrashers, one with a fine riddle underneath the drum inclining downwards, and with a fixed tray over which the straw passes to the discharge; the bottom of this tray is formed of bars running longitudinally, and the grain falls through the space between the

bars into a hopper below, whence it is led out to a delivery at the side of the machine. The second thrasher is similar in construction, but has no riddle under the drum.

We have endeavoured as far as is useful to convey an idea of the leading features in the thrashing machines exhibited by the foreign makers. To give a detailed description would involve a constant repetition, and the names of the exhibitors are to be found in the catalogue. We may, however, mention H. F. Eckert, of Berlin, who had two thrashers showing first-class workmanship. The Prince Liechtenstein's Adamsthal Works, near Osrüna, contributed amongst many other exhibits one simple direct-delivery thrasher, and S. Redinger, of Czernowitz, showed a fixed machine with one broad shaker and a riddle below. An ordinary grooved bar beater and fan contribute to make this a superior machine. Sigl, of Neustadt, Vienna, had one large steam-worked and one small direct-delivery thrasher, both of first-class workmanship. Strobl and Baris, of Buda Pest, Adolf Müller, of Grotau, Horold and Wanger, of Eislingen, P. Gross, of Hohenheim, Rapp and Speisen, of Goeppingen, may be mentioned among the others who all contributed thrashing machines to this Exhibition.

The first impression, on the examination of these implements, was one of surprise that so many foreign makers are engaged on a large scale in this trade, and that they are able to produce machines at prices which almost defy competition.

The Exhibition showed us, too, that, while most of them are more thoroughly acquainted than English makers with the special requirements of the districts they serve, they are, in many instances, fully alive to the progress and improvements made in this country, and they will not fail to make the most of these whenever a demand for refinements in details arises. Several of our leading makers have, it is true, boldly entered into competition with them on their own ground by establishing works abroad, but there are some remaining who appear still to imagine that creating a foreign trade is an easy and straightforward matter. Those who have succeeded know by their dearly bought experience that the reverse is the case, and no English agricultural implement makers can hope successfully to compete with foreign manufactures, unless they know their ground and their customers thoroughly. With these advantages it is still certain that an English originator can hold his own against any foreign copyist, whilst the foreign originator he regards as an honourable competitor, by whom there is no disgrace to be worsted in the commercial struggle.

Horse Gears.

Although not strictly belonging to Agricultural machinery, it will be convenient to include horse gears in this review, as they occupied a prominent place amongst the exhibits of the different makers of machines and implements coming within the section.

At the same time so large a number were exhibited, and there are comparatively so few different types of construction, that it would be tedious to follow them in detail. We propose, therefore, to deal with them collectively, rather than independently, and to classify them as far as possible. Broadly, there were two distinct varieties; those in which the power is taken from a coupling direct, and those through which it is transferred through a vertical shaft to an overhead pulley, either horizontal, and keyed direct on the shaft, or vertical, and driven by bevel gearing.

England.

The class in which the power is taken direct off the shaft was far the more numerously represented. Messrs. Wallis and Steevens, of Basingstoke, exhibited a very well-made four-horse gear, which will serve as a good example, Figs. 111, 112. It is mounted on a carriage frame, adapted also for the transport of a small thrashing machine. The frame is of timber, but to it are bolted a pair of cast-iron brackets, which carry the sockets for the poles, and

receive the bearing of the main shaft. The large driving wheel has bevel teeth, and gears into a small pinion, on the shaft of which is a spur wheel, actuating a pinion, that in its turn drives a universal coupling, to which a shaft can be attached, and the power led off, either to the work itself, or to an intermediate gearing, and thence to the work by a strap. In Messrs. Wallis's gear, the bottom bearing is taken by a dished cast-iron frame, which does not appear to have as much strength as is desirable. A form of gear of which many examples were to be found in the Western, as in the Eastern, Agricultural Halls, is given in Fig. 113, and may be adapted for one, two, or four horses. It will be seen to consist of a timber platform laid on the ground, and having bolted to it a cruciform cast-iron frame, in the centre of which is the bearing for the large wheel. This wheel has bevel teeth, and drives a pinion on a shaft, which also carries the universal coupling, as shown.

Again, Fig 114 shows a type gear of which there were many examples: a frame either in wood or iron (that in the sketch is of iron), with cast-iron brackets, supporting either a bar on top, or a wooden bearer for the vertical shaft bearing and pole sockets. The large wheel has bevel gearing driving a pinion and spur wheel, which increase the speed on a second pinion, to which the driving coupling is connected. The sketch shows also an intermediate bearing and foundation beam, employed when the power has to be transmitted for a considerable distance.

Sweden.

Sweden, as a matter of course, exhibited cheap and serviceable gears, some driving the universal coupling with the bevel pinion, from the main wheel direct, others using intermediate gear, as in Fig. 113, and others again like Fig. 115, in which the driving wheel gears with a pinion on a vertical shaft, and through this drives a pair of bevel wheels, the smaller of which carries the coupling. In Fig. 113 it will be noticed that a small wheel is placed on a spindle upon a saddle bracket bolted to the frame, and in such a position that it bears upon the top edge of the main wheel, keeping it down to its work. Most of the gears were provided with this detail. In the Swedish ones, three, and even four, such guiding wheels are added, and several dispense altogether with independent sockets for the poles, these being fastened direct to the top of the wheel. The Swedish gears are, in fact, arranged and made with a special view to cheapness of construction, combined with durability, and this object they appear to have attained.

Germany.

The Eckert Company showed two fine horse gears, the diameter of the driving wheel in the larger one being 6 ft. Fig. 115 gives a sketch of their arrangement. The form given to the top of the driving wheel will be noticed —four broad plate spokes carrying a platform on top where the pole sockets are placed, and a driver's seat above. The gearing is of the common type, the coupling being on the second shaft. The pressure roller on top of the driving is shown, and it is to be observed that the Eckert Company adopt the practice of bolting up the bevel teeth of the driving wheel, upon the frame, in segments, instead of making them all in one piece with the wheel. Thus the one we are speaking of is divided into eight segments; this arrangement offers a quick and cheap mode of repair if any accident happens to the teeth of the gear.

The smaller implement exhibited by this firm exactly resembled that shown in Fig. 116.

Switzerland.

Of the second class of horse gears—those from which the power is translated overhead,—but little has to be said, and there were but very few examples exhibited. The first is by J. Rauschenbach, of Schaffhausen, in which the poles are attached direct to the wheel, brackets being provided for that purpose; this wheel has internal teeth, and drives a pinion and a large toothed wheel below, gearing into a central pinion keyed on the vertical shaft, and which carries at the upper end a large horizontal pulley, from which the power is taken. This gear is well made.

Messrs. Versell & Co., of Chur, also showed an overhead gear mounted on a three-wheeled carriage. The driving wheel in this machine has a closed top, and internal teeth, which actuate gearing arranged as in the one previously noticed. On the top of the shaft, however, is a bevel wheel gearing into a pinion mounted on the same shaft as a vertical pulley.

Austria.

We have to notice especially the horse gear of Messrs. Clayton and Shuttleworth, of Vienna, and as several imitations of it were to be found in different parts of the building, by referring to the original we shall do full justice to the imitators. Fig. 117 represents their gear, which is mounted on a carriage and has nothing special in point of detail, being simply an arrangement already described. The work is, however, admirable, and the form of framing, cast-iron standards, and general appearance, belongs especially to this firm, and it is these points, the only ones characteristic, and not the workmanship, which have been copied and exhibited.

Bohemia.

One maker, Adolf Müller, of Grotau, in Bohemia, exhibited a class of gear which enjoyed a short lived popularity; it consists merely of a large worm-wheel driven by the horses, and actuating a worm mounted in suitable bearings, and carrying the coupling at one end. Gears of this kind, and in several different sizes, were exhibited by the makers, and while they have their important points to recommend them, namely, that they are cheap, simple, and very fairly made, the wear is excessive, and they do not work freely.

Russia.

Ladislaus Mencel, of Bialazarkoff, showed an overhead horse gear also mounted on a carriage. Like the rest of his exhibits, the machine is extremely well made and very massive, being evidently intended for the rough usage to which he would be subjected in primitive districts. The large driving spur wheel gears into a pinion, and so transfers motion to a central vertical shaft, through a second pair of toothed wheels. In this gear two vertical pulleys of different diameters are driven by the bevel gearing on top of the column.

Messrs. Lilpop, Rau, and Co., of Warsaw, also had a very similar gear, but instead of two they only drive one pulley.

There remains one more gear to be mentioned which belongs to neither of the two previous classes, and which originally came from the United States, but has long since lost the limited application that it enjoyed for a short time.

This is a kind of treadmill horse gear in which there is a long inclined plane, formed by the upper surface of an endless platform, consisting of wooden bars strung together upon axles by means of brackets on the underside of the bars. At the end of these axles are small rollers travelling upon suitable guides, and at both extremities of the machine turning over wheels and passing under the machine. The bars are set so as to present an angle, and afford foothold to the horse, and they are protected from wear by iron plates. At the upper end mounted on the same shaft as the wheels around which this endless platform turns, is a spur wheel with internal teeth, driving a pinion and coupling joint. The platform is wide enough for two horses abreast, which in their perpetual and useless endeavours to reach the top of the machine actuate the gearing.

The horse gears formed undoubtedly an important section in the department under notice, and were very fairly and numerously represented, especially by the foreign makers, who find probably a large and increasing demand for them. In fact, the completeness with which any particular machine was represented among the agricultural exhibits formed a fair indication of its rank and importance.

Chaff-cutting Machinery.

In no other class of machinery amongst the agricultural machinery exhibited at Vienna, was such an amount of ingenuity displayed as in the implements for cutting chaff. The objects to be obtained are the rapid and clean cutting of straw and other stalks in variable lengths, the means employed being revolving, and in a few cases vibrating or reciprocating knives, the straw being fed automatically between studded rollers.

England.

The English leaders of this special industry were probably Messrs. Benthall and Co., of Suffolk, who did not exhibit at all, but whose machines have been largely copied by foreign makers. In their absence, Messrs. Richmond and Chandler, of Manchester, were the most important exhibitors.

In the largest and newest pattern they exhibited, the machine, which may be driven either by hand or power, has a fly-wheel armed with three curved knives, the edges of which are kept constantly sharp by coming in contact, at each revolution, with a steel placed in front of the mouth-piece of the machine. The trough by which the material to be cut is fed to the knives, is at right angles to the frame on which the mechanism is mounted. The shaft to which the cutting wheel is attached, runs in two bearings, and carries a double bevel pinion, cast in one piece, and of the form shown in Fig. 118. Gearing into one or other of these pinions are two bevel wheels, one within the other, the outer and larger one being made with a deep and cylindrical back, to contain the smaller one, and allow space for it to slide to and fro for a certain distance. This sliding motion is accomplished by means of a lever worked at the side of the machine, in a semicircular guide plate, with three notches, corresponding to, out of gear for the centre notch, and fast and slow motions for those on each side. The shaft on which the concentric bevel wheels are mounted, slides to and fro, by the agency of the lever, the larger wheel being on a key way. Now, if the small wheel be advanced, the inner bevel pinion drives it with a quick motion, if it be thrown back, the outer bevel pinion gears into the larger wheel for a slower motion, whilst, in another position, all are out of gear and the machine runs free. At the end of the sliding shaft there is a very broad pinion always gearing on a spur wheel on a lower spindle, whether the sliding shaft be at the forward and backward limit of its travel. In connexion with this spur wheel is a suitable train of gearing, driving the upper and lower feeding rollers, whilst on the shaft itself is a roller, around which passes an endless web formed of wooden bars strung together, and forming the bottom of the trough. By this arrangement a quick motion and a slow one are obtained, and any desired length of cut can be given by the substitution of change wheels for driving the feeding rollers.

In another large cutter of a standard pattern, Messrs. Richmond and Chandler employ a wheel with two knives, and the wheel-shaft carries at its inner extremity a bevel pinion, gearing with a wheel at right angles to it, and driving an ordinary train of wheels for actuating the top and bottom feed rollers. The arrangement for throwing in and out of gear is good. A lever at the side of the machine is connected with a rod, hinged under the frame, and this when moved upwards raises a strap, on the inside of which is formed an inclined rib. This strap passes between two collars on the shaft, and the rib is so disposed that when the strap is raised it strikes one of the collars, forcing the shaft back, and placing the wheel out of gear, while, when it is depressed the other side of the rib passes the opposite collar and brings the shaft back again. The speed in this machine can also be regulated by change wheels, and the feed motion is constant.

In a third and smaller variety, the first motion is again given from the shaft by a bevel wheel, and a similar train of gearing is adopted for driving the rollers. The detail to be noticed is, however, the means employed for altering the speed. Inside the frame in the second driving-shaft is a sliding sleeve carrying two pinions, which can be moved to and fro by a lever, and which gear in one or other of two spur-wheels, through which the feed is

driven, according to their position. This class of machine is the cheapest one made by the firm, with a fixed steel for constantly sharpening the knives.

Another machine has a double pinion and concentric bevel wheel motion, like the one just described; but instead of the mechanical adjustment, the shaft is slipped to and fro by hand, being set by a sliding stop on the side of the machine, and again in another, by a stop turning on a pin and which fixes the shaft in the desired position.

The most primitive machine that was shown had a hand feed, the straw being simply pushed through a comb, and the knife wheel turns on a short spindle. To vary the length cut, one or both knives are employed, for the larger length one blade being taken away.

Altogether, Messrs. Richmond and Chandler's exhibits were excellently finished, and made a first-rate show. Messrs. Lewis and Co., of Shrewsbury, showed several fairly made but very heavy machines, in which the most noticeable detail was the addition of a lever pinned to the frame, and carrying a pair of bars for throwing the strap from the fast to the loose pulley, and the work of altering the speed. This consists in the introduction of an intermediate shaft, on which are pinions of different sizes, and which is slid to and fro by a lever, so as to gear into one of two spur wheels.

Mr. W. N. Nicholson, of Newark, showed a few small but excellent machines. In one of them, a worm on the knife wheel shaft drives two crown wheels, one above and one below, these being on the roller spindles, which are thus actuated. In another for cutting the chaff to two different lengths, the rollers are geared together on one side by a pair of toothed wheels, and on the other the main shaft drives a worm and wheel, whilst a crown wheel can be moved forward into gear for the slower speed.

Sweden.

In the Swedish department there was good work, and generally speaking, original designs of chaff cutters. Thus the Göteborg Mechanical Works showed a large machine, in which the knives are concave on the cutting edges, and on the end of the main shaft is a disc, with a groove cut across its face. This groove is graduated so that the exact throw of a pin working in it may be regulated. From this pin a connecting rod descends to the lower part of the implement. Attached to the crank are two rods, the upper ends of which carry wedge blocks, which fit into the groove of a "silent feed" disc, and when the machine is in operation produce an intermittent motion. The spindle of the feed disc actuates one feed roller, and on the other end carries a bevel wheel. On the spindle of the upper roller is a similar wheel, and working in brackets are two pinions gearing into them, so that a coincident and intermittent motion for both is obtained.

Several copies of Nicholson, besides those of Richmond and Chandler, were to be seen here.

From Ofverum came a chaff cutter, in which the main shaft has a crank, a rod from which goes down to a vibrating board, and works bars attached to it, for moving a pressure bar at the mouth of the implement up and down. This machine is fed by hand, and the two rollers move together by a system of ratchet wheels and frames, the act of pushing the straw through turns the upper roller, and therefrom the lower one. The same works show a "silent feed" machine like the one already noticed, but the detail for moving roller is much neater. It is shown in Fig. 119, and will be seen to be arranged as follows:—On the spindle of the lower roller driven by the feed is a crown wheel, and a second similar one on the spindle of the upper roller. Brackets attached to the side of the implement carry a vertical and drop pinion, which is driven by the lower and drives the upper crown wheel.

Switzerland.

We now come to certainly the most ingeniously arranged chaff cutter exhibited, that of M. H. Bünzli-Rodmer, of Ustar, in Switzerland. Fig. 120 shows the principal parts of the mechanism. The fly-wheel shaft *a*, runs in

two bearings, and close to the fastest one a cam *c*, is mounted on the shaft. This cam is of the form shown in the sketch, with two inclined planes. When revolving, these inclines come in contact with a freely running coned roller *d*, mounted loose on the arm *e*, which oscillates in the centre e^1. In a piece with the arm *e* is a finger *f*. At the back, and hinged on an independent centre, as shown, is a segment rack *h*, retained by the weighted pawl *i*. From the face of this rack projects a finger *g*, and on raising the pawl the rack can be turned, and the finger *g* brought nearer to or further away from *f*, the changes of position being regulated by the number and pitch of the rack teeth. On the spindle of the lower feed roller is a ratchet wheel *o*, with a weighted detent *j*, pinned to the side of the machine, and two others, *k*, k^1, also weighted, and turning on an arm forming part of the crank e^1, shown in dotted lines, and loose in the spindle of the feed roller. The arm *e*, and the crank e^1, are coupled by a connecting rod, shown in dotted lines, behind the main shaft. At d^1 and d^2 are shown the ends of two shafts, which pass under the frame to the other side of the implement, and in connexion with d^2 are two spiral springs, of which one is shown at *p*. These springs are fastened back to the frame, and serve always to keep the pawls *k* and k^1 fast against the ratchet teeth. Now, when the shaft and cam *c* are turned, the latter comes in contact with the roller *d*, and forces it forward, while the arm on which it is mounted turns round the centre e^1. But as soon as the finger *f* strikes against *g*, the forward motion ceases, and the roller merely revolves, so long as the cam path is in contact with it. By this simple arrangement, it will be seen that the range of motion to and fro may be regulated from one tooth of the ratchet segment to the full length of its arc. The forward motion thus imparted is communicated to the loose crank e^1, and the pawls k^2 and k^1, which drive the ratchet wheel through a greater or less number of teeth, according to the way in which the rack segment *n* is set. With each stroke the spiral springs *p* are extended, and bring back the rod d^2, with the pawls, into position. The spindle *d*, which passes under the frame to the other side of the implement, has a crank attached to it, from which, in a manner similar to that just described, the ratchet wheel driving the upper feed roller of the machine is moved.

There is, in addition, a pressure board, which rises and falls at the mouth of the machine. This is driven by means of a cam *l*, on the main shaft, pressing against a small roller *m* twice in each revolution. The roller is mounted at the end of one arm of a bent lever *n*, the other arm bearing against the underside of the pressure board frame. The cam *l* is so arranged as to lift the board at the moment when the feed rollers bring forward the straw to the advancing knife. It will be seen, from the foregoing description, that this implement is susceptible of very easy adjustment for cutting different lengths and that it has an intermittent feed, two great advantages in a chaff cutter. Moreover, these results are obtained with very simple mechanism, and the only drawback appears to be the introduction of the pawls and ratchet wheels which are exposed to much greater wear than toothed gearing. But this same objection applies with greater force to the majority of the chaff cutters in the Eastern Agricultural Hall.

Germany.

The Eckert Company showed two chaff cutters, of which the larger is driven by power. On the main shaft and between the pulleys and the knife wheel, which has two cutters, there is a bevel wheel, from which the train of wheels for driving the rollers is driven. As there are four rollers, the amount of gearing is very considerable. The machine has at least novelty to recommend it. The knife wheel shaft is formed with a crank, and a connecting rod takes hold of a vibrating bar near the bottom of the machine. This bar moves up and down the side rods of a pressure block, and on the outside of one of these rods is a projection, on which rests the end of a long lever, hinged far back to the side of the machine. Attached to this lever are two arms, carrying each a pawl at the end, one a driving and the other an arresting pawl. These gear into a ratchet wheel on the feed roller spindle, which it

drives. There is only one feed roller in this machine, with a number of radial ribs upon it, arranged parallel with the axis.

There is on the same vibrating bar a second similar pair of pawls, which drive a second ratchet wheel below. This wheel actuates the driving roller of an endless wire web, that feeds the straw through the rolls.

A chaff cutter by P. Kurz, of Rippberg, showed a revival of a long abandoned English mode of driving the rollers and obtaining variable speeds. Fig. 121 shows the arrangement. On the driving shaft is a sliding pinion, which can be locked in four different positions, corresponding to four concentric rows of teeth on a disc, as shown. This gives a constant feed only, but it is a simple form, and several copies were to be seen in different parts of the hall.

M. J. Fraas, of Wunsiedel, Bavaria, had a heavy implement, the only noticeable point about which is his mode of obtaining a double speed, which differs only slightly from many others. Two bevel wheels, of different diameter, mounted on a sliding shaft, are thrown to and fro by a clutch lever, as shown in Fig. 122. The whole machine is, however, complicated, and presents few points for commendation.

P. Arnhofer, of Leibnitz, exhibited two or three guillotine machines, which are of very limited usefulness. The knife is driven from a crank in a shaft at the top of the machine, and at the end of the shaft, opposite to the fly wheel, is an eccentric moving a rod with a driving pawl at the end working the feed rolls. We may dismiss this type of chaff cutter in a few words; there were not many examples to be met with, and all of them were more or less complicated and inefficient. The same holds good of the vibrating knife machines, of which two or three were also exhibited.

J. Exner, of Geske, had a machine showing originality of detail, but promising little for durability. The main shaft extends for a short distance by the side of the trough, and terminates in a bevel wheel, which drives a second at right angles to it. The shaft on which this latter is mounted terminates with a slotted crank for varying the feed. Three arms are mounted on the crank pin, one short one going back to a pin on the frame, and the two others carrying at their ends driving pawls, by which the rollers are actuated. An intermittent motion is thus obtained, but apart from the objection to the ratchet feed, the parts are badly proportioned and ill-made.

J. Müller, of Jenbach, showed the only "silent-feed" motion in the Eastern Hall. With one more description we may conclude this notice of chaff cutters. This is the type of machine that was shown by Weil, of Frankfort-on-Maine, Blessing, of Hemmingen, and one or two others. At the end of the main shaft there is a slotted crank which gives motion to an adjustable pin for altering feed. On the pin is a bent lever, passing under the frame of the machine to the other side, where it carries a system of bell-cranked levers, armed with driving pawls, and actuating ratchet wheels on the rollers. These machines were in each case very well made, but were, we believe, copied from some obsolete English pattern, abandoned on account of its complication.

We may safely state, after an examination of these machines, that with one or two exceptions the only good ones that were shown were the copies of Benthall Richmond and Chandler, and Nicholson. The originality displayed showed very little mechanical aptitude, and indeed there is little doubt that those makers who confine themselves to imitating the machines of the English makers, do the safest and best trade, for those makers have justly earned a reputation on the Continent, and carry on there a large trade, despite the efforts of enterprising copyists.

Crushing Mills.

The machines for crushing corn, beans, and other seeds next claim our attention, and a very brief notice of these will suffice, because only few makers exhibited in the English section, and in the Eastern Agricultural Hall there was literally nothing to remark of these implements but that the few exhibited were copied from English patterns.

The roller mills of Messrs. E. R. and F. Turner, of Ipswich, formed the best, and, indeed, the representative exhibits. They consist essentially of a large broad wheel mounted on a frame, and in contact with a small smooth cylinder. The large wheel, driven either by hand or power, causes the small wheel to revolve, and the seeds passing between them are crushed. In order to prevent the rollers from being damaged, if a stone or other hard foreign body is fed between the rolls, the bearings of the small cylinder are free to slide in bearings made in the frame, but are kept up to their work by a rod on each bearing, which is connected with a spring. A small wheel and screw at the back of the spring serves to set the cylinder as desired. On one end of the spindle of the cylinder is a small pulley, and this, by a strap, drives a second pulley mounted on the spindle of a feeding fluted roller at the bottom of the hopper. The width of admission to this roller is regulated by a slide, moved in the larger machines by a small rack and pinion and lever. In one size of mill exhibited there is mounted on the same frame a beam and main Kibbler for breaking up the seeds. It consists of a hopper similar to the one just described, mounted on a circular casing around the spindles of the large crushing wheel. The breaking apparatus comprises two parts, one a coned disc fast on the spindle, and the other a ring concave. Both disc and concave are formed with deep angular serrations, set in opposite directions, and the beans falling between are more or less broken, according to the clearance between the two faces. A means of adjustment is provided with a ratchet wheel on the end of the main spindle, which sets the disc and ring at any desired distance apart.

Messrs. Hunt and Tawell, of Earl's Colne, Essex, exhibited a crushing mill in which two large wheels of equal diameter are employed. In this mill a spring is introduced, as in the Turner mill just described. Some very good duplicates of this machine were to be found in the Eastern Agricultural Hall.

Messrs. Richmond and Chandler, of Manchester, showed some very good corn crushers, in which a pair of spirally fluted rollers are employed. These rollers are driven by double gearing, and the mills, which need no detailed description, show exceedingly good workmanship. The space between the rollers can be regulated by two adjusting nuts and screws in front of the frame.

Of cake crushers Messrs. E. R. and F. Turner, and Mr. Nicholson, of Newark, were the only exhibitors we need mention. The former showed two or three mills of different sizes, the larger ones with two pairs of rollers, the distance between each pair being adjustable by means of a lever and serrated nut, moving upon a segment provided with corresponding serrations. In breaking cake for sheep or beasts the upper and larger rolls are employed, while in preparing food for lambs the lower rolls are thrown into gear, and receive the partially broken cake from the upper rollers.

In Mr. Nicholson's machine an ingenious arrangement is adopted for adjusting the space between the upper pair of rolls. On the spindle of one roll there is mounted a wheel with internal teeth. Gearing into this wheel is a pinion actuated from the shaft of the fly wheel. The spindle of the roller is free to move in a circular path to a sufficient extent to obtain the maximum clearance desired. During this movement the toothed wheel rolls around the pinion, always keeping in gear with it. The lower rollers, when fine crushing is not required, may be thrown out of gear, and the distance between them is regulated by a lever and eccentric, the toothed wheels always remaining in gear, but not engaging deeply in each other when the rolls are separated.

Root Cutters.

The class of machines for pulping and cutting roots were better represented in the foreign sections than the crushing mills, but we may dismiss them with the same remark as that we made about the latter, namely, that they were copies from English patterns, modern and antique. These machines are of three kinds, those for cutting the roots into small fragments, others for cutting slices, and those for cutting rectangular lengths or "fingers." For the first

purpose a series of small teeth-like knives are employed, for the second continuous curved blades, and for the third straight short knives.

Messrs. Hornsby and Co., of Grantham, exhibited perhaps the best show of these implements, and as they have gained distinctions repeatedly, we may give some space to the description of their machines. In the pulper there is a large hopper, one side of which is entirely open, whilst the other three sides converge and die away into a line at the bottom. Against the open side of the hopper is placed a disc, mounted on a spindle, and to which a rapid motion is given by hand or power. Six rows of holes are made in this disc, radiating from the centre towards the periphery. The holes taper from the inner to the outer face of the disc, where they are considerably larger. Below these holes are rows of knives, or teeth, each independent of the other, and secured in place by a key. On the disc spindle there is an eccentric, which gives motion to a bar, which carries a number of projections so formed and arranged as to pass between the knives on the discs, when the latter is revolving to clean them, and also to feed the roots to the knives down to the last piece in the hopper. The combined action of the knives and the reciprocating bar produces excellent work. All the roots pulped of course pass through the holes in the disc, as they have no other place for exit.

In the slicing machine a similar hopper and revolving disc are employed; but two continuous knives of the same form as those generally used for chaff cutters are mounted upon the discs, and are attached to it by bolts. A clear space is left behind the knife for the cut slices to fall outside the disc into the receiver below.

This same machine may be adapted for cutting the roots into "fingers" by detaching the continuous knives, and substituting special cutters. These cutters are simply pieces of steel, with a right-angled bend in each, one side forming the cutting edge, and in the other an oval hole is formed, through which a set screw passes for attaching it to the seat framed for it outside the disc. In the larger machine there are altogether 26 of these cutters, placed in a curved path, corresponding to the sweep of the slicing blade, and the seats made to receive them are stepped around this curve and at right angles to the disc. The opening in the disc plate, through which the slices cut by the continuous blade pass, are thus interrupted by a series of knife edges, the distance apart of which is about equal to the width of the opening. Square pieces are thus cut, and pass freely through the opening, because, as the seats for the knife blades are all tangential to the curve around which they are stepped, the space between the blades are tapered, and the cut roots cannot bind.

All these machines of Messrs. Hornsby's are extremely well made, and are placed on the market at a very low price. The same remarks hold good of Mr. Nicholson's pulpers and cutters, which differ in no particular details from those of Hornsby.

Messrs. Hunt and Tawell, of Essex, showed several of this class of machines and one of Gardiner's machines for cutting "finger" pieces. In this case the knives are mounted around the periphery of a cylinder placed at the bottom of the hopper of the machine, and the roots being thrown in, are cut by the advancing knives. The mill is now, we believe, but little used, as it has many disadvantages; it bruises the root, and will not cut down to the last piece like the machines of Hornsby and Nicholson.

Corn Screens, &c.

Whilst all the chief makers of corn screens in this country, Penney and Co. of Lincoln, Ransome, Sims, and Head, Colman, and Co., Hornsby and Rainforth, were represented in the Western Agricultural Hall, this class of agricultural implements appears to be almost unknown amongst the foreign makers, excepting Pernollet and Lhuillier (both French manufacturers), at least if we may judge from the absence of such machines from the Eastern Agricultural Hall. At the same time it must be mentioned that though no

such exhibits appeared, corn screens figure in the catalogues of German, Austrian, and Hungarian exhibitors, all of them copies, and mostly from Pernollet, of Paris, and Lhuillier, of Dijon.

ENGLAND.

In noticing these exhibits, therefore, our attention will be confined exclusively to the Western Agricultural Hall, and first in order is that of Messrs. Penney and Co., of Lincoln.

This firm showed several screens, both single and combined, with winnowing machines. The construction of this screen can be briefly explained. It consists of a continuous spiral wire wound into a cylindrical form, with a sheet iron spiral inside, and at intervals spaced around the inside of the cylinder, spiral springs extend from end to end, to which each wire, forming the cylindrical cage, is attached. In some of the screens exhibited these spiral springs are outside the cage. Through each of the spirals passes an irod rod, fastened by a nut at one end to a circular open frame, to which also one end of the circular cage is fastened. This frame is rigidly attached to a spindle, which passes through the middle of the cage, and revolves in bearings upon the frame at each end. This spindle is made hollow, and contains a long screw the end of which projects beyond the extremity of the spindle, and is made square. A long slot is formed in the upper side of the spindle, and passing through it is an arm forming part of a nut mounted on the internal screw. This arm is attached to an open circular frame carrying the other end of the cylinders, and the bars within the spiral spring. The broad internal worm is also fastened both to the fixed and sliding frames. It is clear that by turning the screw within the spindle, the sliding frame will travel along the spindle, and the spiral wire forming the cylinder will be expanded or contracted, altering the spaces between each coil.

In the largest size of screen two cylinders are employed, mounted on the same axle, but with movable frames at each end, and a fixed central frame, to which the inner end of each cylinder is attached, and the screen is expanded from each end, one half being set with a coarser pitch than the other, in order to obtain a regular gradation from end to end.

In those screens with external spiral springs, the long brush which is placed near the top, and in contact with the cylindrical cage, is made to revolve by means of a pinion gearing on a spur wheel on the main spindle; but in those screens with internal spiral springs, no gearing is required, and the brush is driven by the revolving cylinder. All these implements exhibited by Messrs. Penney and Co. were well made, and of their ordinary standard patterns.

The screen of Messrs. Ransome, Sims, and Head, of Ipswich, is on an entirely different system, and is very ingeniously arranged. Fig. 123 shows its form and construction. It consists of two cylindrical cages, each formed of one continuous spirally laid wire, and of such a pitch that there is space between the wires for one cage to be laid into the other, so that when the wires of each are thus interlocked and present a flush surface, there is very little clearance between the wires, but if one cage is raised a little, the space increases, so that by regulating the height through which the movement takes place, the space between the wires can be absolutely adjusted.

The screen is mounted, as shown, upon a frame with two wheels, so that it can be easily transported. The axis of the cylinder is as usual slightly inclined, and the spindle upon which it runs rests in bearings at the end of the frame. As we have said the cylinder consists of two distinct cages, one laid upon the other, and each is carried by a separate circular frame at both ends. Between these frames, and on the outside, bars extend, held by a bolt to a lug at each end. The inner face of the bars is formed with short teeth, the distance apart of which corresponds to the pitch of the spiral wire forming the cage, the spiral being all fastened to the teeth of the bars. On the frame in front of the machine is a double segment with a lever working within it. The segment is pierced with holes, and the lever can be set to any position by a locking pin. The lever is connected with an eccentric keyed on the through spindle, and a corresponding eccentric is placed at the further end of the

screen. The outer circular frames of the screen are mounted on a sleeve upon the spindle, and revolve freely upon it. These frames are in close contact with the corresponding pair of inner frames to which the second wire cage is attached, the set of toothed bars before spoken of as secured to the spiral wire of the cylinders being attached to the outer frames, and the other to the inner ones. By turning the lever moving in the quadrant, the eccentric and spindle running through the cylinder are raised, lifting at the same time the cylinder which is mounted on the eccentrics, the other one remaining stationary. This movement is very slight indeed, all that is required being to increase slightly the clearance between the wires. At the upper end of the cylinder and inside it is a coned screen for arresting stones or other foreign bodies too large to pass the spaces between the wires while the grain escapes into the cylinder. Mounted on the frame of the implement exhibited is a winnowing machine, and the hopper above contains a fluted feeding roller, while the feed is regulated by a slide and lever. Motion is given by means of a fly-wheel and handle, the latter so set that it is rigid only in one direction, and doubles back if the machine be driven the wrong way. On the further end of the fly-wheel shaft is a bevel pinion, gearing into a toothed ring around the end of the cylinder. The fan of the winnower is driven by a pulley, and the feeding roller above by a small strap from this pulley to a second on the roller spindle. Altogether this corn screen of Messrs. Ransome and Co. is the most ingenious but not the most practical one exhibited, and it requires, what is given to it, first-class workmanship.

Messrs. Coleman and Morton exhibited a corn screen of a totally different arrangement, and none the less commendable for ingenuity. It consists of two hexagonal frames fixed rigidly upon a spindle, and connected together at each angle by a bar. At the front end is a second hexagonal frame, but free to slide upon the spindle, the motion being controlled by a wheel and screw. The angles of this frame are placed midway between those in the fixed frame, and bars pass from these angles to the back of the machine, where they are so attached as to adjust themselves to the slight movement given to the shifting frame in adjusting the gauge. The space between each member of the framing is filled in with a series of small bars of triangular section, with a flat side uppermost, and attached to the frame by rivets. The ends of each bar are made flat so as to bear truly on the frame. The adjustment of the screen will be at once understood. By turning the hand wheel on the spindle, the shifting frame recedes or advances, and alters the angle formed by the series of bars between the frame, as these bars are not rigidly attached. When the latter are at right angles to the frame, the spaces between the bars are at a maximum; when the movable frame is drawn back to its full extent, the bars are nearly in contact.

No brush is used in this implement, but, instead, a leather roller, pressing against this twelve-sided cage for its whole length. It is said that this leather roller is more durable than a brush, and, altogether, that the machine is an economical and efficient one. There appear, however, to be too many parts about it, and it must be an expensive machine to make, although the selling price is very low.

Messrs. W. Rainforth and Co., of Lincoln, showed a corn screen on their usual pattern. This is the screen so largely adopted in thrashing machines, and which answers extremely well. It consists of a woven wire fabric covering a worm, and thus formed into a cylinder, fixed at one end, and movable at the other. By drawing the forward and moving frame upon the shaft, the screen is elongated, and the size of the meshes increased.

Finally, in the English department, we come to Messrs. Hornsby's stand, who showed a corn screen of their own pattern. Upon the same system as that of Penney's, it is certainly a more simple implement. It consists of a continuous wire coiled into a cylindrical form, but, instead of the longitudinal bars and spiral springs of Penney, there are employed a series of bars arranged spirally inside the cylinder, and to these the wires forming the latter are attached. A revolving brush is placed outside in contact with the wires. The forward end of the machine is, of course, adjustable, and, by extending or contracting it, the spaces between the wires can be regulated. That this is a

very excellent screen has been shown by experience, from its extended use, and by its performances at different trials.

The implements exhibited were simple screens as well as those combined with winnowers and stone screens. In all cases the price is extremely low.

Messrs. Clark and Dunham, in the English section, showed one of Lhuillier's machines, referred to presently, evidently from the works of that manufacturer, although shown as their own exhibit. The same firm had two smut machines, the most complete one of which consists of a vertical cylinder, with a fixed frame of cast iron, and perforated plates. Within this cylinder, and driven by a pulley at the upper end of a shaft, are a series of spiral beaters, which violently agitate the grain, fed in from the top, separating the smut from the grain, and both falling together to the bottom, where they are exposed to the action of a blast from a fan forming part of the apparatus. The blast drives the smut from the machine, while the grain falls into a suitable receptacle.

France.

In the French section two makers exhibited corn screens—M. J. Pernollet, of Paris, and M. Lhuillier, of Dijon.

One type of these, by the former maker, consists simply of a cylinder mounted in the usual manner, and formed of an open frame surrounded with four different kinds of perforated plates, the sizes of the perforations representing the different classes of seed, or impurities to be separated. The cylinder is turned slowly—about twelve revolutions per minute—and, as the grain travels along, what can escape falls through one or other of the different perforations into a corresponding trough below. The machine is arranged so that the perforated plates may be changed at will for different kinds of work. It is but fair to say of this machine that the samples exhibited of its performance were excellent, but they were scarcely such as would be met with in regular practice.

Fig. 124 shows a different, and very ingenious, type on the Lhuillier system. The mixed grain is fed from a hopper into the lower part of the cylinder. The inside of this cylinder is fitted with small hemispherical indentations placed close together. At the lower part of the cylinder is a tray, extending for its whole length. A revolving motion is imparted to the cylinder by a strap at one end, driven off a small pulley on the principal shaft, and a reciprocating movement is also given by a system of levers worked from a crank shaft in the lower part of the machine. By this combined motion the grain fed into the cylinder is kept in continual agitation, and the seeds smaller than the good grain lodge in the indentations before spoken of, and are carried round as the cylinder revolves, many of them falling into the tray before mentioned. In order, however, to dislodge any seed that may remain in the indentations, each time that the cylinder makes a revolution, a hammer, actuated by a cam, strikes the outer side, and the shock effectually throws the seeds into the tray. The illustration clearly explains the construction of this ingenious machine, which, we believe, works extremely well. At M. Pernollet's stand, separators, on the Lhuillier system, were to be seen, but much simplified, the vibration of the cylinder and the hammer being omitted.

Corn Dryer.

Messrs. Davey, Paxman, and Co. exhibited their well-known corn-drying apparatus, which is illustrated in Figs. 125, 126, 127, 128, 129. It consists of a long inclined cylinder, containing several internal ones, as shown in the section.

The cylinder marked B extends from end to end, formed with a tapering end piece, and terminating in trunnions, one of which carries a spur wheel, and is caused to revolve by the pinion shown in Fig. 129. Steam is admitted into the cylinder by the pipe G, passing out through M. Outside the cylinder B are a number of perforated beaters D, arranged spirally, and having brushes which revolve in contact with the inner side of a larger cylinder C. This latter forms an annular chamber, to which steam is admitted and which escapes through a suitable opening. Finally comes the outer cylinder

K, to which air is admitted. In the annular space formed between the cylinders B and C, a blast is admitted from the fan L, which meets the corn as it advances through the machine. The corn is fed into the hopper *a*, which is furnished at the bottom with a feeding roller *o*, and it falls thence into the chamber, which is in open communication with the perforated beater bars D. In traversing the length of the machine the corn is exposed to the drying action of the steam contained in the cylinder B, and the annular space outside, and at the same time is subjected to the action of the blast from the fan, while it is violently agitated in its passage by means of the brushes and the holes in the beater bars D. These machines are altogether a speciality of Messrs. Davey, Paxman, and Co., and the very large trade in them which they carry on, speaks for the efficiency of the arrangement.

There remains for consideration little further of interest in exhibits of this and a similar class throughout the Western Agricultural Hall. There were a few corn separators, notably two or three by M. Pernollet, of Paris, consisting of large open trays, with intricate partitions formed in them, between which the grain and foreign bodies thread their way, and finally take different roads, according to their various specific gravities. The corn is fed from a hopper, and the tray, mounted upon highly elastic legs, receives a rapid oscillating movement from suitable mechanism. Of the actual value of this machine we can form no opinion. The motion imparted appears to endow the mass of grain with superior intelligence, but sample work is as fallacious as samples themselves are.

We have already said that no corn screens, or analogous machines, were to be found in the Eastern Hall. A few of the chief makers include them in their catalogues, but we believe they buy them, and do not attempt the manufacture. Whether the demand is not sufficient to encourage them, or whether these makers are not able to manufacture screens properly, we do not know. Probably both causes combine to check them from entering into competition with English makers.

We may take this opportunity of saying the few words necessary about the winnowing machines that were exhibited. While in the Western Hall a large number were to be found, these machines were to be seen in abundance in the Eastern Hall also. Many of them were of excellent workmanship, but call for no special notice on account of their arrangement and design. Some, on the other hand, were contrived in the most unmechanical manner possible, and as these possess neither interest nor influence in this branch of agricultural machinery, we may dismiss them also without notice.

We have now taken our readers through all the various branches of agricultural mechanical industry, as it was represented at the Vienna Exhibition, and we have endeavoured, as far as possible, to call attention to those things worthy of notice, and to bring out such salient points as may be of service to the English manufacturer in his foreign trade.

RAILWAY ROLLING STOCK.

Railway carriages and wagons, likely locomotives, were largely represented at Vienna; but, as in the case of locomotives, the exhibition was a purely continental one, and it therefore lacked some of the variety which it would have possessed had English and American builders contributed to the collection. Of the various continental nations Austria was by far the largest exhibitor, and next, of course, came Germany. Thus, if we omit the hospital or ambulance trains, which formed a special section, we find Austria showed twenty-nine vehicles; Germany, twelve; Belgium, four; France, three; Russia, three; Switzerland, two; and Italy, one, besides a special exhibit of

the carriages used for the service through the Mont Cenis tunnel. France indeed was not represented in this section at all until long after the Exhibition had opened, except by the admirable ambulance train of MM. Bonnefond, of which we shall speak in its proper place, while English makers did not put in any appearance whatever, and America only showed a street tramway car, which we can scarcely include amongst railway rolling stock. It is a necessary consequence of this state of affairs that, as we have said, the collection of railway carriages and wagons at Vienna was purely an exposition of Continental practice, and although this fact by no means diminished the interest of the collection in the eyes of English or American engineers, yet it undoubtedly lessened its value as a whole.

One feature which could not fail to strike the English railway engineer in examining the rolling stock collected at Vienna, was the very extensive use made of "composite" under-frames, or, in other words, of under-frames, made partly of iron and partly of timber. Frames made wholly of timber are, in fact, very rarely met with on the continent, while the use of frames constructed wholly of iron is by no means general, the most extensively adopted practice being to make the soles of I-iron or C-iron, and the rest of the frame of wood. Under-frames so made, if well put together, are undoubtedly very rigid and substantial, while an inspection of vehicles, which have been some time in use, shows that they stand well, and are, of course, free from "hogging," —that but too frequent complaint of frames made entirely of timber.

Another feature which will be noticed is the general absence of through tie-bolts. As a rule these are wholly dispensed with by continental builders, the binding together of the soles and transverse bearers, &c., being effected solely by corner irons or by short bolts passing through the soles and having flat ends, which are in their turn bolted to the transverse bearers. We ourselves prefer the through tie-bolts generally used in English practice, and we believe that their employment could be introduced with advantage in the case of the composite frames. Turning to the bodies, too, we find that in the continental carriages the panels are almost universally made of iron, a material which, although undoubtedly durable and very applicable in many respects, is yet inferior to wood in its power of securing an equable temperature, while the vehicles fitted with such panels are generally more noisy when running than those in which the panels are of wood or papier-maché.

The collection of carriages at the Vienna Exhibition was also distinguished by the large proportion of vehicles containing sleeping accommodation, about half those shown being either regular sleeping carriages, or carriages having their seats arranged so that they may be converted into more or less comfortable couches. The great variety of arrangements exhibited are instructive and interesting,—particularly at the present time, when there is a growing demand for good sleeping accommodation on European lines,—and we shall take occasion to consider them in detail.

In describing the railway carriages and wagons at the Vienna Exhibition, we propose to commence with those of Austria, and before speaking of the exhibits in particular, it may be well that we should say something respecting Austrian railway carriages generally.

Austria.

It is the general opinion on the continent that the German railways offer more conveniences to the traveller than English lines, and this is an opinion which is often shared even by Englishmen themselves. The travelling experiences of the numerous visitors to Vienna during 1873 will, however, have served to spread a correct idea of the working of German railways, and have shown their advantages and disadvantages in a true light; and we may remark here that the great difference between the construction and working of railways in England and Germany renders it a duty for the English engineer to study minutely the system adopted in the latter country whenever the opportunity is afforded him.

The construction of the Austrian railways is in principle similar to that of the German lines, but the latter differ considerably from the former with respect to the amount of traffic, this being much larger in Germany than in

Austria. A different position has also been secured for the railways in the former country, through the national character of the German people, the better financial circumstances existing, the greater activity of the German engineers and the greater reliability of the officials; the consequence being that German railways are, generally speaking, more solidly constructed, are more fully provided with rolling stock, have a greater proportion of double lines, and more practical traffic arrangements than those of Austria.

The Austrian railways are, in fact, distinguished more by the fine external appearance of their stations, buildings, &c., than by the practical character of their arrangements, and greater care is taken to provide for the wealthier classes than for the general public. For nine-tenths of their length the Austrian railways are only single lines, and it must be remembered that they traverse a country a great extent of which is as yet in a state of inferior civilisation. The stations at Vienna and Prague are nearly all fine buildings, with large halls, and luxuriously fitted up waiting rooms, but the stations in the provinces rarely offer the least comfort, and are merely arranged to satisfy the modest demands of a half-civilised people. At most of these stations the passengers have to pass a considerable distance from the waiting rooms to the trains, and have to cross on their way lines of rails over which the goods traffic is carried on, a risky proceeding, the results of which are seen in the fact that about two-thirds of the accidents on Austrian railways happen at stations. The waiting-rooms are everywhere filled with tobacco smoke, whilst no special rooms for ladies are provided.

The Austrians have a very high opinion of their passenger carriages, which are, in fact, commodious and lofty, and which are provided with well-made springs and wheels, the tyres and axles of the latter being generally of Bessemer steel. The best arranged are the third-class carriages, which are entirely covered, and have doors with glass windows. They are, however, inferior in some respects to the newer third-class carriages on English lines, while they share with the latter the want of some provision for small hand luggage. The second-class carriages are, however, less comfortable, notwithstanding that they are all provided with stuffed seats and backs, and with three glass windows on each side of each compartment. The seats in a great number of these carriages are too high for any but very long-legged passengers to get anything like a comfortable rest on the floor for their feet. Besides, the seats and backs are, on several lines, covered in a most inconvenient manner with smooth leather, so that the passengers are always sliding about, and never get into a fixed position. More comfort is, however, obtained on other lines where the seats of the second-class carriages are covered with cloth.

The Austrian first-class carriages are fitted up in an exceedingly luxurious manner; gilding, costly woods, velvet, mirrors, and silk curtains being used lavishly, if not in all cases with great taste. The fittings of these carriages also include many small conveniences, as, for instance, small tables, bags, hooks for hats, &c., which ought to make them very comfortable, but which are often arranged with so little practical sense, that the desired purpose is fulfilled in but a very imperfect manner. Even in these carriages the seats are inconveniently high, and are but too often stuffed with such a disregard of the anatomy of the human form divine, that the passenger cannot obtain an easy position. One of the greatest inconveniences of the upholstering, however, consists in the great softness and elasticity given to the seats, this being so great that the passenger is kept in a state of perpetual motion when the carriages are running. In chairs or sofas used in a room the elasticity of the seats may be very great and yet only be productive of extra comfort, but in a railway carriage, where the whole structure is more or less in motion, a great amount of elasticity in the cushions gives rise to a constant friction between the head and shoulders and the back or arms of the seat, and thus renders comfortable rest impossible. Even in a reclining position this great elasticity of the seats is, as we know from experience gained during night travelling over Austrian lines, productive of discomfort instead of the luxurious ease it is intended to promote. The deduction to be drawn from this is, that to obtain comfort the vibrations due to the motion over an imperfect road

should be destroyed by springs or other appliances before reaching the seats, and that the latter should be only very moderately elastic.

Most of the seats of Austrian first-class carriages can be pulled out, so that the opposite cushions may be brought together, and thus form a very convenient bed. Some of the compartments are arranged as coupés, and contain a sort of sleeping arrangement formed by pulling out the seat, which, together with the back, is thus brought into an inclined position. A suitably arranged flap at the end of the compartment being next let down, a bed is formed that would be very convenient, if the position and inclination of the cushions were well chosen; on some lines, however, as, for instance, on the North-Western Railway of Austria, the length of the bed is not sufficient for even a moderately tall man, and owing to defects in carrying out the details, none of these arrangements offer the same comfort for a night's rest as the use of the "sticks" in our own first-class carriages in connexion with our horse-hair cushions.

It appears to us rather curious that on Austrian lines the sleeping accommodation is allowed to be used only in express trains, and that the seat arrangements of the carriages we have mentioned are at once made fixed as soon as the carriages form part of another train. It seems to be the intention of the authorities to, in this manner, force people to travel by express trains, the fares for which are about 25 per cent. higher than for the others, and this, although express trains in Austria do not travel quicker than our slow trains, averaging, say, 25 miles per hour, inclusive of stops. For the use of a sleeping seat a special charge is made.

The lighting of the carriages is very imperfect—a defect which also exists on many of our own lines—reading during the night being an impossibility. Gas is nowhere adopted, and the lamps are often so placed in the partitions of the carriage above the nets for the luggage, that the latter darkens the lamps absolutely. We found this objectionable arrangement also on German lines, especially on Saxon railways, the newest carriages of which are of a very uncomfortable construction. One of the characteristic attributes of the Austrian carriages are the mirrors with which they are fitted, these being sometimes fixed so high from the floor that no lady can use them, whilst on their account the luggage rails are divided, so that one passenger in each compartment finds no space for his hand baggage. In the Austrian carriages little or no provision is made for the passengers keeping with them the large pieces of their luggage, the same want of accommodation for portmanteaus, &c., also existing generally on German lines, where all the luggage is given over to the company for conveyance in the luggage van—a system which would be the cause of most inconvenient delays with the large traffic on the main lines in this country. In Austria the space below the seats of the carriages cannot be used for the storing of luggage, because it is much reduced by the cushions of the seats, these cushions being between 10 in. and 12 in. thick.

The compartments are mostly, as we have said, very commodious, and have usually a clear width of from 2·5 to 2·6 metres (8 ft. 2½ in. to 8 ft. 6¼ in.) and a length of from 2 to 2·2 metres (6 ft. 6¾ in. to 7 ft. 4⅝ in.) for first-class carriages; of 1·8 metres (5 ft. 10 in.) for second-class; and of 1·7 metres (5 ft. 7 in.) for third-class carriages; whilst the height of all the new carriages is seldom less than 2 metres (6 ft. 6¾ in.) in the centre. Many of the Austrian lines have introduced fourth-class carriages, in which the passengers have to stand; but these carriages are covered and they are provided with glass windows. These carriages, fourth-class, are generally used in industrial districts where a number of men have to be conveyed over a short distance.

Many carriages on the American systems with two four-wheeled bogies, which were formerly exclusively used on Austrian railways, are now to be found in trains which are not called mail or express. These carriages are, however, exceedingly inconvenient for handling at stations, they are heavy, and the sitting space is limited on account of the longitudinal passage. The clearing of people from these vehicles is also much too slow, on account of their having only two doors for about 70 passengers, so that often people who want to come in are in the way of those who want to come out. The whole

arrangement of these carriages is unpopular in Austria, and public opinion has strongly protested against their being adopted for international traffic. When the working of the principal Austrian lines—namely those from the Turkish frontier at Basias *viâ* Pesth and Vienna to the German frontier, and from Trieste and the Italian frontier at Cormous to Vienna—passed into the hands of French companies, the more convenient carriages with four wheels and four compartments (very similar to the carriages on English railways) were substituted for the vehicles on the American system, which latter are now used only occasionally for slow trains.

In Germany and Austria the large six-wheeled passenger carriages, with five or more compartments, which were there once in general use, have been nearly everywhere abandoned, and smaller carriages with four wheels have again been adopted. The inconvenience of handling the large carriages, and the impossibility of using for them small turntables, have been no doubt the cause of this change, although it cannot be denied that the larger carriages run easier than the shorter ones. On some of the Austrian lines saloon carriages are in use, these being luxuriously fitted up, and containing generally beside the saloons, a sleeping compartment and a toilette. These carriages are, however, not so much employed by the public, for whom they are of little practical use; but they are kept for the conveyance of distinguished passengers and high officials, and they have mostly been built for the members of the boards of directors, in order to offer the greatest convenience to their travelling.

The heating of all carriages during the winter has been ordered by the Austrian ministry, but as the Government has little power over the administrations of the railways, this order is executed in but a very doubtful manner, especially in those classes of carriages which require it the most, namely, the third and fourth.

The English passenger, when travelling in Austrian carriages, will notice with little comfort the heavy rattling and jingling that surrounds him, disturbing his night's rest and exciting his nerves in a painful degree. The cause of this is that but few of the means long used in England to secure quiet running, have been adopted in Austria. The panels of the carriages are not made as in England of wood or papier-maché, but of thin sheet iron, which can never be so firmly secured as to prevent shaking, and which conducts the sound and the heat in a more disagreeable manner than the former materials, thus making the carriages hotter in the summer and colder in the winter. Pads of india-rubber between body and frame are seldom applied, and wooden disc wheels, which so greatly improve the easy running of carriages, are practically unused on Austrian railways, although we noticed in the Exhibition four carriages for Austrian lines—one of them, a hunting saloon for the Emperor—which were fitted with them. Finally, the custom has been adopted of providing passenger vehicles with brakes fastened directly and rigidly to the body of the carriage, the play of the springs thus ceasing at once as soon as the brake is put on.

Leaving generalities, however, and returning to the consideration of the rolling stock shown at the Vienna Exhibition, we shall, of the numerous Austrian exhibits, take first in order those contained in the pavilion of the Emperor Ferdinand's Northern Railway—a pavilion which we have previously mentioned in our report on locomotives, as being situated behind the eastern end of the Machinery Hall. We propose to describe these exhibits first, not only on account of their interest, but because they include many details which have been generally adopted in Austrian practice, and which it is desirable should be first described in connexion with the exhibits of the railway on which they originated.

One of the most prominent exhibits in this pavilion was a sleeping carriage constructed for the Emperor Ferdinand's Northern Railway, by Messrs. Klett & Co., of Nuremberg; the carriage, which has been built from the designs of Herr Becker, the locomotive superintendent of the line, being intended for the direct traffic with the Russian and Roumanian railways. This traffic necessitates long runs, and hence there has arisen in connexion with it a demand for sleeping accommodation, and for carriages having small compartments

sufficing for parties of two or three persons only, with conveniences for servants. It was to meet this demand that the carriage of which we are now speaking was designed, and the manner in which the end has been obtained is shown by the outline views of the carriage given on Plate CXXVII. Referring to these figures it will be seen that this carriage is furnished at each end with a kind of enclosed platform or antechamber, to which access is gained by side steps. These antechambers are, as will be seen from the plan, narrower than the main body of the carriage, so that the steps project but slightly laterally beyond that body. The length of the body over all, including the antechambers, is 25 ft. 11 in., and its width 9 ft. 8 in.—a much greater width than could be accommodated on our English railways.

From the antechambers access is obtained into the body of the carriage through end doors opening into a longitudinal passage which extends the whole length of the body on one side of a central longitudinal partition. This partition rises—as will be seen from the cross section—nearly to the full height of the carriage, and on one side of it the body is divided by cross partitions into three compartments, each containing one long and one short seat, as shown in the plan. The longer seats accommodate, if necessary, two passengers, while at the end of the shorter seat a bracket table is provided, as shown in the plan and transverse section. These tables are also intended to be used as washstands, and above each of them is fixed a mirror, while a reading lamp is provided, and fixed in a convenient position. The compartments just mentioned are shut off from the longitudinal passage by doors with two leaves, so that each compartment is independent of the other. For night use the two seats of each compartment draw out, so as to meet, the back cushions then folding down, as shown in the part section of Fig. 1., Plate CXXVII., so as to form a good bed. At the same time sleeping accommodation for a second person can be provided in each compartment by lowering down a bed which, during the daytime, is shut up in an inclined position against the roof of the carriage. This upper bed is shown lowered in the central part of Fig. 1, while in Fig. 2 it is shown on the left side in its closed, and on the right side in its lowered position. The two beds thus provided in each compartment are very roomy and comfortable.

On the other side of the longitudinal passage there are, as will be seen from the plan, four seats disposed in pairs, these seats, however, not being shut off from the passage. For night use the seats of each pair are drawn out, so as to meet each other in the same way as in the opposite compartment, while above each pair of seats another bed lowers down in the same manner as those of which we have already spoken. The carriage thus contains altogether ten beds, while for day use it has seats for thirteen persons. The carriage also contains a lavatory and a water-closet, these being arranged on the same side of the central passage as the open seats of which we have last spoken; and, if desired, the end compartment opposite to them can be reserved for ladies only, a curtain across the central passage being, if necessary, employed to shut off this part of the carriage from the rest.

The carriage is 8 ft. 4 in. high at the sides, and 10 ft. 5 in. high in the centre, the middle portion of the roof being raised as shown in Figs. 1 and 2. The sides of the body are straight, without any "fall under," and the body overhangs the under-frame to a considerable extent on each side, the soles being placed closer together than is usual. The soles are of iron, of **I**-section, and the rest of the frame is of wood. The carriage is carried on two pairs of Mansell's wooden disc wheels, and the axle boxes are of the standard pattern adopted on the Emperor Ferdinand's Northern Railway, a pattern which we shall describe in due course. The workmanship of the carriage is excellent, and the interior fittings are elaborately finished. The continuous central partition, however, by completely dividing the carriage longitudinally, gives each portion the appearance of being cramped, although, in reality, both the seats and beds are commodious.

The carriage we have been describing is fitted with an arrangement of heating apparatus which has been designed and patented by Herr Thamm, the chief engineer, and Herr Rothmüller, the manager of the workshops of the Emperor Ferdinand's Northern Railway. This apparatus is now being largely

adopted in Austria, and in addition to being fixed on many of the carriages at the Vienna Exhibition, it was exhibited detached in the pavilion of the Emperor Ferdinand's Northern Railway.

The engravings on Plate CXXVII., showing it as fitted to a third-class carriage, will explain its construction clearly. From the various views given, it will be seen that by means of vertical and horizontal partitions a kind of box or casing is formed beneath the under-frame of the carriage, this casing containing, in the centre, the heating apparatus proper. This apparatus consists of a horizontal sheet-iron cylinder, having a door at one end containing a cage or grated box for the fuel, this box having a cover of iron wire. The fuel consists of a mixture of charcoal and coke, and the air for supporting combustion enters through an ashpan riveted to the bottom of the cylinder, the amount of air thus admitted being regulated by adjustable slides. From the inner end of the cylinder casing the products of combustion are led off through a copper pipe arranged as shown, this pipe eventually passing out through the wooden casing, and being provided at its end with a kind of hood, so constructed that the draught of air rushing through the hood when the carriage is running causes an induced current to be produced in the pipe, and thus creates a draught through the apparatus.

Over the sheet-iron cylinder above mentioned is placed a casing or mantle of ∩-shape, this casing being also of sheet iron, and being provided with a couple of branch pipes or flues, which extend right and left to the bottoms of the compartments. Holes admit the cold air from the carriage to this casing, where it is warmed and returned to the carriage through the pipes just mentioned. The heat radiating from the apparatus and the pipes warms the air enclosed in the external casing, openings in the floor allowing this warmed air to ascend into the vehicle.

At the two sides of the apparatus are trumpet mouthed tubes for collecting fresh air for admission to the carriage, these tubes communicating with a hollow protecting partition placed directly over the combustion cylinder, so as to protect the under-frame from the heat radiated by the main part of the apparatus. The fresh air, heated by traversing this partition, is admitted to the carriage through suitable ventilators. Ventilators also are fixed near the ceiling of each compartment for the escape of the foul air, and for the regulation of the temperature.

This arrangement of heating apparatus we have just described was introduced on the Emperor Ferdinand's Northern Railway in the winter of 1871–72, and it has proved most successful. Twenty pounds of the mixture of coke and charcoal is found sufficient to maintain a carriage heated during a run of twelve hours, a temperature of abont 55° Fahr. being maintained in the vehicle, whatever may be the temperature of the external air. The apparatus also affords good ventilation for the carriages, and the temperature near the floor of the latter is always higher than near the roof. It is also found that the apparatus requires no attention during the run, while its arrangement is such that access to the draw springs, &c., is readily obtained. Altogether, the apparatus appears to serve its purpose exceedingly well, and it is, as we have said, being extensively adopted.

The other examples of rolling stock exhibited in the pavilion of the Emperor Ferdinand's Northern Railway, consisted of a high-sided goods wagon and a covered goods wagon, both being excellent specimens of workmanship. Each of the wagons is carried on four wheels, and each has soles of I-iron, and the rest of the frame of wood. The high-sided wagon (which is shown on Plate CXXVII.), is 16 ft. 1 in. long, by 7 ft. 10 in. wide inside, and the sides are 3 ft. 11½ in. high. The side pillars are fixed to cast-iron brackets, which are in their turn bolted to the outside of the soles, the clips or washer plates through which the pillar bolts pass being made long, and extending some distance up the pillars, so as to afford a good support for the latter. The wagon is fitted with two doors on each side, these doors opening upwards, and being supported when raised by iron brackets hinged at the side of the doorways. When the doors are closed these brackets fold against the inside of the sides of the wagon, but it appears to us that they must be liable to be damaged during loading. The wagon is carried on two pairs of Ganz's cast-iron disc wheels with

chilled tyres, and it is fitted with springs having fluted plates. The drawbar is continuous, and the draw spring as well as the buffer springs are volutes.

The covered goods wagon, to which we have above referred, is 20 ft. long by 7 ft. 11 in. wide inside, and 7 ft. 3 in. high at the centre. The side pillars are carried by brackets, as in the wagon of which we have just been speaking. The overhanging floor at each side, in both this and the wagon last spoken of, is supported by a longitudinal angle iron, which runs under the outer edge of the floor from end to end, resting on the brackets to which the side pillars are attached. The covered goods wagon has sliding side doors, and both wagons are made of splendid timber, and have all the iron-work got up bright. The covered wagon is carried on ordinary wheels, with wrought-iron spokes and cast-iron bosses, the bosses being exceedingly heavy. The buffers and draw apparatus are the same as in the other wagon. Both the wagons illustrate useful types, of which large numbers are now in use, there being about 3,700 such wagons running on the Emperor Ferdinand's Northern Railway, and about 4,300 on other lines.

Neither of the wagons above spoken of is fitted with a brake, but amongst the details exhibited in the same pavilion was an example of an arrangement of brake which has been extensively adopted on the Emperor Ferdinand's Northern Railway. This arrangement of brake has been designed and patented by Herr F. Langhof, inspector on the railway just mentioned, and it is represented by Fig. 10, Plate CXXVIII. From the views there given it will be seen that the brake hangers are double, each side or cheek being made in two parts, which are hinged together just above the brake blocks, in addition to being hinged to the frame as usual. The bars which form the upper part of the cheeks are set outwards, so as to form a shoulder at the joints with the lower bars, this shoulder serving to limit the movement of the lower part of the cheeks with respect to the upper. Each brake block is placed between the two cheeks of its brake hanger, and is secured in position by a screw which forces a plate up against its under side, and thus presses it against another plate at the top of the block. Both these holding plates have points projecting from them, and both are so connected to the cheeks of the hanger as to be able to adjust themselves so as to obtain a fair bearing on the block. Besides holding the block in place, these clipping plates also serve to prevent its splitting, the block being inserted in the hanger so that the end of the grain bears against the wheel. The manner in which the brake rods are connected to the hangers will be readily understood from the engraving.

The extra joint in the brake hangers above described enables the brake blocks to adjust themselves properly to the wheels, whether the carriage is loaded or unloaded, and thus prevents vibration, while the brake blocks, acting with the end of the grain of the wood, are found to give a better holding power and to better withstand wear and tear. The arrangement likewise facilitates the fitting of the brake blocks, while the latter can also be very readily set up when worn. The blocks may also, if necessary, be each made up of several pieces of timber, as these pieces will be firmly bound together by the clip plates. This arrangement of brake has been applied to several hundred carriages on the Emperor Ferdinand's Northern Railway, and has given very satisfactory results.

In addition to the brake above described, Herr Langhof is the inventor of an arrangement of carriage windows, of which an example was also exhibited in the pavilion of the Emperor Ferdinand's Northern Railway, and of which we give views on Plate CXXVII. The object of this arrangement is to exclude dust and prevent shaking of the window sashes, and this it does very successfully. To the opening in the door occupied by the window sash is fitted a wooden frame just capable of sliding freely inwards and outwards, this frame being of such width that when the sash is up it closes the top of the "well" into which the sash is lowered. To the under side of the lower bar of this frame is attached a plate spring, as shown in the vertical section and plan, this spring tending to always keep the frame pressed against the window sash. At the top the frame is hinged to the door frame. The edge of the frame bearing against the sash is covered with leather, and it thus has sufficient frictional hold on the sash to keep the latter raised in any position it may be

placed, while it at the same time prevents rattling, and by bearing closely against the sash for its whole height excludes dust. When the window has to be lowered the frame is drawn inwards by the act of pulling on the strap attached to the sash frame. The contrivance is a good one, and as we know, from travelling in carriages fitted with it, it acts well. The frame also makes a neat finish to the window, and by closing the opening to the "well" prevents anything from being dropped into the latter. The arrangement is now being extensively adopted in Austria. While speaking of this door we may direct attention to the manner in which the glass is fixed in the sash frame, the latter being made with loose pieces on one side which press against the glass, and are secured by screws, as shown in the elevation. It will be noticed also that the standing pillar has fixed to it a wide strip of stiff leather, which overlaps the door and serves as a finger guard, preventing fingers from being shut in the door. This protecting strip of leather is very generally used on the continent, and it no doubt prevents accidents.

Another detail shown in the pavilion of the Emperor Ferdinand's Northern Railway is an example of the standard carriage buffer used on that line. This buffer is shown by Fig. 11, Plate CXXVIII. It consists, as will be seen, of a wrought-iron ram with a wrought-iron head riveted to it, this ram moving in a case also of wrought-iron. The buffer contains two volute springs, which are guided by a rod through the centre of the buffer as shown, this bolt bearing at the front end against a wooden block on the ram. The stroke of this buffer is $4\frac{1}{2}$ in. and its weight 150 lb. There was also exhibited a buffer with cast-iron ram and casing, this buffer containing a single volute spring of larger size, but being of the same weight and having the same range as that we have described. This buffer is shown by Fig. 12, Plate CXXVIII.

The last detail exhibited in the pavilion of the Emperor Ferdinand's Northern Railway, of which we have to speak here, is the standard axle-box for carriages and wagons, of which views are given on Plate CXXVII. The whole of the carriage and wagon axles on the Emperor Ferdinand's Northern Railway are, we should state, lubricated with mineral oil, Mr. Ludwig Becker, the present locomotive and carriage superintendent of that line, having been one of the first—if not indeed the very first—railway engineer to employ such oil for lubrication to any large extent. As long ago as 1861 Mr. Becker, who was then locomotive superintendent of one of the Austrian State railways, commenced experimenting on the lubrication of railway axles with mineral oil; but at first with unfavourable results. Mr. Becker, however, persevered with his trials, and in 1863 the difficulties had been, to a great extent, surmounted, and a large number of carriages were running regularly with this lubricant, the result being a most important saving in cost of lubrication. The first Austrian railway on which the mineral oil was largely employed was the Empress Elizabeth's Western Railway, on which line the axle-boxes are almost all of the class known in Austria as Paget's, the space below the axle bearing being packed with wool, and the lubricant being employed to saturate this packing. On Mr. Becker being appointed to his present position on the Emperor Ferdinand's Northern Railway, he naturally extended his application of mineral oil for lubrication; but in order to do this successfully some further experiments had to be made. The axle-boxes in which the oil had been previously employed were lubricated from below, in the manner to which we have referred; but with the exception of those fitted to about 300 vehicles, the axle-boxes in use on the Emperor Ferdinand's Northern Railway were all lubricated from above, while the bearings in use were composed of 60 per cent. lead, 20 per cent. antimony, and 20 per cent. tin, a mixture differing materially from that with which the most successful results had previously been obtained. Mr. Becker, however, continued his experiments, and eventually arrived at most satisfactory results, the standard type of axle-box finally adopted being that shown in the illustrations. Before this, however, Mr. Becker had used the ordinary axle boxes, but with the grease space above the bearing packed with wool and saturated with the mineral oil; and we have been favoured by Mr. Becker with some interesting statistics as to the relative consumption, &c., of the boxes thus fitted, and the "Paget" box already referred to. From these it appears that the Paget boxes were filled up every two months, each box

taking about half a zollpfund, or say 0·55 English pound of oil, while the wool stopping lasted from 12 to 14 months, during which period the vehicle would run from about 12,500 to 15,000 English miles. The consumption of oil per axle-box was at the rate of 0·000816 English pound per English mile, while the wear of the bearing was at the rate of 1 lb. per bearing for each 31,000 miles run.

The axle boxes lubricated from the top—the top space being filled with wool—required, on the other hand, to be oiled every 100 to 150 miles (English), and this was, of course, an inconvenience; but as a set off against this the economy of lubricating material was greater, the consumption being only at the rate of 0·000653 lb. per bearing per mile.

The axle-box finally adopted, and which is illustrated on Plate CXXVII., is of a very simple type. It consists, as will be seen, of the box proper fitted with a cover having on its underside a semi-cylindrical recess to receive the bearing. This latter is composed of a mixture of 50 per cent. of lead, 25 per cent. of tin, and 25 per cent. of antimony, and it is provided at its ends with flanges which prevent it from turning round on its seat. The box beneath the bearing is filled with a cushion of lime-tree shavings, and a plug at the front provides the means of supplying additional lubrication in cases of emergency. At the back the box is closed by two half discs of wood, which are cut away so as to lap each other where they meet, and which are held together by a steel wire ring introduced into a recess turned in their outer sides, as shown in the longitudinal section of the box. This steel ring, by its elasticity, causes the wooden discs to clip the axle closely, and takes up any looseness caused by wear, the arrangement being a very neat and efficient one.

The two parts of the axle box are secured together by four bolts, and the top cover is furnished with a screw plug for the introduction of oil, and with a well-fitting secondary cover, by removing which access can be had to the lubricating wick. The arrangement of this wick constitutes the most important feature in the axle-box, and we must, therefore, describe it in detail. Mr. Becker soon discovered, in the course of his experiments on the use of mineral oil as a lubricant, that where this oil is supplied through a wick, it is most essential that this wick should be properly proportioned and arranged. It was to insure this uniformity in the proportions of the wicks that the arrangement we are about to describe was devised.

Referring to the views of the axle-box on Plate CXXVII., and to the full-sized view of the wick on the same Plate, it will be seen that the cotton strands are passed through a tube of sheet iron, this tube being inserted in a cork plug, which fits the hole in the axle-box. By this arrangement a wick can be removed and replaced by a new one with the greatest readiness, and the men who attend to the oiling of the axle-boxes on the Emperor Ferdinand's Northern Railway are never allowed to tamper with the wicks, but have strict injunctions if a wick is out of order, to remove it altogether and replace it by a new one. The renewal of the wicks in the lubricating plugs, as we may term them, is performed by one man, whose duty it is to prepare the wicks for the whole line, and by this means it is secured that the wicks are all composed of a proper number of strands and are fitted up in a strictly uniform manner.

The results which have attended the introduction of this system have been most satisfactory. The boxes of the passenger carriages are oiled every four weeks, and those of the wagons every eight weeks, and, as we have stated, mineral oil is used for lubricating all vehicles. The consumption of oil per axle-box per English mile is only 0·00047 lb., while the experience on the Emperor Ferdinand's Northern Railway shows that the number of hot bearings is equivalent to each bearing running hot once in 19 years. The axle-boxes exhibited at Vienna, and they were in excellent condition, had been in use from the 18th of March 1872 to the 18th of April 1873, during which time they had run 96,128 kilometres, or 59,700 miles without being repaired or examined. Besides being employed universally on the Emperor Ferdinand's Northern Railway, Mr. Becker's arrangement of axle-box is being extensively used on other Austrian lines, and in 1873 about 16,000 vehicles were running fitted with them.

Besides the rolling stock exhibits, of which we have now spoken, the pavilion of the Emperor Ferdinand's Northern Railway contained locomotives and locomotive engine details, of which we have already treated in our report relating to those subjects, while it also contained other exhibits with which we shall deal in due course. Altogether, in fact, this pavilion contained the most interesting collection of railway exhibits at Vienna.

Taking next in order the carriages in the Austrian section of the Machinery Hall, we shall speak first of the exhibits of the Grazer Waggon, Maschinenbau und Stahlworks Gesellschaft (formerly J. Weitser & Co.) of Graz. These makers showed two carriages, one being the first-class with sleeping compartment, which forms the subject of Plate CXXIX., and Figs. 1 to 9, Plate CXXVIII., while the other was a composite carriage constructed for the Emperor Franz Josef's Railway.

The former carriage was constructed from the designs of the managing director of the works, Herr W. Eckerth, and it is, as will be seen, a four-wheeled vehicle, the body containing a sleeping compartment with lavatory and watercloset, an ordinary first-class compartment and a first-class coupé. The general dimensions of the carriage are :

	ft.	in.
Length of frame - - - -	22	$9\frac{1}{4}$
Width between soles - - -	6	$0\frac{3}{8}$
Wheel base - - - - -	12	$5\frac{5}{8}$
Length of body inside - - -	20	$4\frac{7}{8}$
Width „ - - -	7	$10\frac{1}{2}$
Height „ - - -	6	$6\frac{1}{4}$

The carriage has a frame of the composite construction, to which we have before alluded as now being so extensively adopted on the continent, the soles being of channel iron, and the rest of the frame of timber. All the forgings connected with the frame, such as the footboard hangers, the draw-hooks, &c., are exceedingly well finished off, and the smith's work is throughout excellent. Beneath the centre of the under-frame is fixed a heating apparatus on Thamm and Rothmüller's system, an arrangement which we have already described when speaking of the exhibits of the Emperor Ferdinand's Northern Railway.

The body of the carriage, which has iron panels, and is made with a considerable "fall under," is supported by ten india-rubber cushion springs placed five on each side, as shown in the side elevation and transverse sections. These springs are arranged in the manner introduced in this country by Mr. George Attock, of the Great Eastern Railway, the india-rubber rings being carried by brackets bolted to the outer sides of the soles, as shown by the detail view, Fig. 1, on Plate CXXVIII. In the carriage we are describing, however, the cast-iron brackets, *a*, form casings enclosing the india-rubber rings, a rather neat arrangement, which, so far as we are aware, has not been used here. The plan is, however, open to the objection that the state of the india-rubber springs cannot be readily seen. The pressure is transmitted to the india-rubber rings by a cast-iron plunger *d*, which takes a bearing against the bottom side of the body, this plunger being held firmly by a cotter which is passed through it and the bolt *e*. The bolt, *e*, is continued through the bracket, and carries an india-rubber ring below the latter, this ring acting as a check spring. The space left between the body of the carriage and the under-frame is one inch.

The longitudinal or lateral movement of the body on the frame is prevented by radius bars arranged on Reifert's system, as shown by Figs. 2 and 3, Plate CXXVIII. Thus at each end of the bottom sides of the body is fixed a bracket C (see Fig. 2), connected by a radius bar B, with another bracket riveted to the sole A; this arrangement allowing the india-rubber cushion springs to have free vertical play, but preventing end motion of the body on the frame. In the same manner side motion is prevented by similar radius bars or links extending each way from a stud E (Fig. 3), fixed at the centre of each headstock, to brackets F on the body.

It will be seen, on reference to Plate CXXIX., that the carriage is furnished at one end with an open gallery, and that access to the sleeping compartment is gained from this gallery by an end door, which opens to a

central passage leading between the water-closet on the one side and the lavatory on the other. The roof over the open gallery is supported by wrought-iron corner pillars, and the gallery itself is protected by a wrought-iron railing, of which, although we cannot praise the design, it is only just to say that it was an admirable piece of smithwork.

Besides being accessible from the end gallery, the sleeping compartment also communicates with the adjoining first-class compartment by a central door, the whole arrangement, which is very convenient, being thus a kind of combination of the English and American systems. The carriage is, as we have already stated, warmed by Thamm and Rothmüller's apparatus, an apparatus which is being extensively adopted in Austria with most satisfactory results, it serving not only to maintain a steady temperature, but also efficient ventilation. The keeping of the carriage cool in summer and warm in winter is also assisted by its being made with a double roof, there being arranged over the doors ventilators, by means of which the external air can be either admitted to or excluded from the interval between the two roofs at pleasure.

In designing the internal fittings of the carriage under notice much ingenuity has been displayed, and many of the details deserve special description. Thus, in the first place, the sleeping compartment, instead of being provided with fixed seats, contains a couple of movable fauteuils, which can be transformed into sleeping couches, and arranged in any desired position. The fauteuils were designed by the engineer to the Graz Works, Herr Ferlich, and the details of their construction are shown by Figs. 7, 8, and 9, on Plate CXXVIII.

Referring to these views, it will be seen that the skeleton of these fauteuils or sleeping couches consists of a frame A, with rounded corners, carried by four legs, B, furnished with castors. Inside this frame, A, there are fixed at the sides iron guide bars, *c*, these bars fitting into grooves *d*, formed on the outer sides of a second or sliding frame, C. This latter frame can thus be pulled out into the position shown by Figs. 1 and 8, the limit to its movement being determined by the projections, *f*, striking against the iron stop pieces, *g*, fixed to the frame, A.

When drawn out in the manner just described the frame C is supported at its outer end by a pair of legs F, and it carries a cushion P, as shown, thus forming an extension of the seat S. When the fauteuil is closed up, so as to form merely a seat, the cushion P^2 occupies the position P^1 beneath the seat proper; but it is drawn out to the position P with the extension of the frame C, of the latter into the position P^2, as indicated by the dotted arcs in Fig. 7. To enable it to be turned over in this way the cushion is mounted on a pair of pins or trunnions *i*, these pins sliding in the grooves *h*, formed on the inner sides of the frame C. The turning over of the cushion also brings down the legs F; these legs,—which are connected by the transverse bar H, and which turn on pins X,—previously occupying a horizontal position above the cushion when in its position P. When lowered to the position in which they are shown in Fig. 7 the legs F form a support for the frame G.

The cushion S has fixed to it at its hind end, the nut *n* fitting on the screw *m*, and by turning this screw by means of the handle *l*, the cushion can be placed at any desired angle. The back of the fauteuil is also adjustable to an inclined position by the arrangement shown in Figs. 7 and 9, there being catchplates K on each side of the seat, and the construction being such that, by exercising a simultaneous pressure on the two knobs M (placed outside below the arm-rests N), the notched bars L can be slid back the required distance. Referring to Fig. 9, it will be seen that the shank of each of the knobs M passes through a slot *o* formed in the corresponding sliding bar L, and is furnished at its end with a kind of T-head, which engages with one or the other of the three notches formed on the inner side of that bar, being kept pressed outwards by the spring *q*. On the knobs being pressed inwards the T-heads of the shanks clear the notches, and the bars L are then free to slide, and the back of the seat, turning on the joint at Q, can be adjusted to the desired angle. To raise the back again, it has evidently only to be lifted by hand, when the notches in the bars L secure it. Altogether, as we have said, the details of these fauteuils are ingeniously arranged, and they enable the seats to be very readily con-

verted into convenient and comfortable couches. In the longitudinal section of the carriage on Plate CXXIX., one of the fauteuils is shown arranged as a couch.

In the central first-class compartment the opposite seats draw out in the manner very generally adopted on the continent, an improvement on the ordinary arrangement having, however, been effected by making the backs follow the seats, so that the back cushions or "squabs" form very convenient pillows. In the end coupé the seats also draw out in a similar manner, while flaps, hinged to the end of the carriage, can be folded down so as to meet the seats, and thus form three sleeping couches.

All the compartments are very luxuriously upholstered. In the saloon or sleeping compartment the fauteuils are covered with a crimson, or rather a kind of cherry-brown rep, while the curtains are of a similar coloured silk rep lined with silk, and the spring blinds are of green silk. The trimming of the lower part of the compartment is of silk of a colour to match the fauteuils, while the upper part is of white and grey silk, with gilded cornices. In the other compartments the seats are trimmed with crimson plush, the upper parts of the walls being covered with white oilcloth, while the curtains and blinds are of green silk. The exposed woodwork is, in all the compartments, of mahogany with walnut mouldings. The floor of the carriage is of parquetry, and is covered by carpets.

The lavatory and watercloset are well fitted up, the water supply being carried by a reservoir on the roof. The water supply to the closet is actuated by the lifting or lowering of the lid of the seat as follows: Below the level of the main tank is fixed a small tank provided with an inlet cock on a pipe leading to the main tank, and an outlet cock on a pipe leading to the pan of the closet. These cocks are coupled so that when one is closed the other is open, or *vice versâ*, while they are also connected to the cover of the seat, the arrangement being such that when the lid is raised the upper cock is opened, and the subsidiary tank filled, while when the cover is closed the lower cock is opened, and the contents of the small tank discharged into the pan. The flap which closes the mouth of the discharge pipe is also actuated by the cover of the seat, it being closed when this cover is raised and opened when it is shut down.

The space available for the central passage being of course limited, the doors of the lavatory and closet have, for convenience, been made in two wings, and to cause these wings to open and close simultaneously they have been fitted with the arrangement shown by Fig. 4 on Plate CXXVIII., this arrangement having been designed by Herr Fauland, the chief foreman of the Graz workshops. Referring to this figure (which is an inverted plan) it will be seen that the lower hinge pins of the wings of the doors are formed with squares, on which are placed the small spur wheels *a*, *a*, these wheels gearing into racks formed in the diagonal sliding bar *b*, *b*, which is guided by the rollers *c*, *c*. It is evident that with this arrangement, if either wing of the door is pushed either inwards or outwards, the other wing will be simultaneously moved in the same direction. The whole arrangement is made on a plate like a lock, and sunk into the floor of the carriage.

The locking arrangements for the two-winged doors are somewhat complicated—in fact we consider unnecessarily so—and they are shown by Figs. 5 and 6 on Plate CXXVIII. In the first place in one wing of each door is placed a lock actuating vertical bars (L and N, Fig. 6), of which we shall speak presently, while in the frame above the door there is fixed another lock, represented by Fig. 5. This lock is provided with a catch F, which, when down, enters into recesses formed in the upper edges of the two wings of the door, and thus holds them fast, but which, when raised (as shown in the figure), is held in that position by a detent A entering into a notch Z, as shown. This detent A is always pressed towards the notch by the spring K, while the catch F, which turns on the pin *a*, is always pressed down by the action of the spring J. On the pin *a*, there also turns a kind of bell-crank tumbler S, the horizontal arm of which is provided with a pin *s*, which projects through the plate of the lock *b*, while the vertical arm has a nose *c*, which bears upon a tail-piece of the detent A. In the figure the parts are

shown in the positions which they occupy when the doors are open; if the latter be closed one of the wings strikes against the pin *s*, thus turning the tumbler S, and causing the nose *c* to depress the tail of the detent A, thus releasing the latter from the notch Z, and allowing the catch F to fall and secure the doors.

The arrangement for opening the doors, when thus secured, is shown by Fig. 6, which is for convenience drawn with the bars L and N laid in a horizontal position, although on the door the lock stands vertically, the bar L extending upwards, and that marked N downwards. The tumbler M is actuated by the ordinary handle, and by turning it the bar L is slid upwards, when it raises the catch F, shown in Fig. 5, and keeps it raised until the door is opened clear of the pin, *s*, when the detent A comes into action, and the catch F is held in its raised position. The weight of the bar L, assisted by the spring A, effects its withdrawal when released. To secure the door on the inside, when closed, the tumbler O (Fig. 6) is provided, and by turning this to the left by a suitable handle the bar N is forced down, when the incline R, being brought to bear upon the incline S (formed on an arm connected with the bar L) holds down the bar L, and thus locks the whole mechanism. On the tumbler O being turned back again, the spring P forces up the bar N, and the bar L is thus free to be used for raising the catch F of the lock at the top of the door, pressed in the manner we have already explained. It is undoubtedly a fact that much ingenuity has been expended in devising the system of locks we have described, but the same end could certainly, as we have already said, have been obtained by more simple means.

Those windows of the carriage which are fitted with sliding sashes have the latter arranged so that they stay in any desired position, while between the two end windows with which the coupé is provided is placed a mirror. The carriage is lighted at night by four roof lamps, arranged as shown. In concluding our notice of this carriage we should state that the workmanship is, in all essential particulars, very good, but the finish of the cabinet work of some of the fittings is certainly not equal to that which would be turned out from one of our leading carriage shops here.

The other carriage exhibited by the same firm was, as we have said, a composite carriage, and it was built in all respects to the specifications of the authorities of the Emperor Franz Josef's Railway, it forming one of an order in course of execution for that line. The under-frame is of the same construction as that of the first-class carriage above described, and the body, which is also mounted on india-rubber cushion springs, is divided into one first-class compartment, one first-class coupé, and two second-class compartments. The coupé is too contracted to be comfortable. The carriage is mounted on four wheels, all fitted with a brake, this brake being actuated from a covered guard's seat provided on the roof at one end. The carriage has outside buffers, a continuous draw bar with volute draw spring, and the axle boxes are made for oil lubrication. The vehicle carries nine first-class and 16 second-class passengers, or 25 in all, and its weight empty is 9 tons. The carriage—which was well made—was shown as a specimen of the ordinary workmanship of the firm, and had not been specially finished for exhibition.

We have already stated that the large number of sleeping carriages was a prominent feature in the collection of rolling stock at Vienna, and we propose next to notice a vehicle of this class exhibited by the Bubna Waggons Fabrik, of Prague. This carriage, of which engravings are given in Figs. 1, 2, and 3, Plate CXXX., is one constructed for the Empress Elisabeth's Western Railway, and is intended for the accommodation of the Empress of Austria, while it is worthy of special notice also from the fact of its being the first carriage turned out at the Bubna Works, that factory having previously been devoted to wagon building only. The principal demensions of the carriage are as follows:—

	ft.	in.
Length of body outside - - -	24	$1\frac{3}{8}$
Width „ „ - - -	8	$6\frac{3}{4}$
Height „ at sides - -	6	7
„ „ centre - -	7	$5\frac{7}{8}$
Wheel base - - - -	13	$5\frac{7}{8}$
Total length over buffers - -	27	8

The frame is of composite construction, the soles being of I-iron—9$\frac{5}{16}$ in. deep, and placed 6 ft. 7$\frac{3}{16}$ in. apart from centre to centre—while the rest of the frame is of wood. The wheels are solid wrought iron, and the bearing springs are long, and appear rather light. The draw-bar is continuous, and is provided with an india-rubber draw-spring, while the buffer springs are also of india-rubber. In front of the doors there are provided footsteps which may be raised or lowered, these steps, which are shown in the side elevation, being necessary to afford easy access to the carriage, as the stations on Austrian railways are without platforms.

Between the body and the under frame there are interposed twelve india-rubber cushion springs, these springs being carried by cast iron brackets bolted to the soles, while end or transverse motion of the body on the frame is checked by radius bars applied in a somewhat similar manner to that resorted to in the case of the carriage from the Graz Works described above. The floor of the body is strongly framed, and is composed of two layers of planking laid with crossed joints and glued together, whilst above this planking is fixed the parquetry work which forms the floor proper. The roof of the carriage is made double, the roof-sticks being arranged between the inner and outer planking.

The general arrangement of the carriage will be readily understood on reference to the plan, Fig. 2, Plate CXXX. From this view it will be seen that a door on each side of the carriage gives access to a central transverse passage A, having a clear width of 2 ft. 11$\frac{1}{4}$ in. On one side of this passage a door opens into the saloon B, while on the other side are the lavatory C, and water-closet D, a short longitudinal passage, 2 ft. 3 in. wide in the clear, being led off between the two last-mentioned compartments, and giving access to the sleeping compartment E. The arrangement is a convenient one, and the space available has been well utilised.

The saloon B is 9 ft. 10$\frac{1}{2}$ in. long by 8 ft. 0$\frac{3}{8}$ in. wide inside, and is richly trimmed with a light drab silk rep, the mouldings being white and gold. The fittings consist of a couch, extending across one end, as shown, a couple of chairs, a couple of round stools, and a table which unfolds and forms a mirror, while mirrors are also placed on the door and walls.

The floor of the saloon is covered by a soft Turkey carpet, and the compartment is lighted by two large roof lamps. The communicating passages, together with the water-closets and lavatory, are panelled with parquetry work with mahogany and gilt cornices, and the floors, as also that of the sleeping compartment, are carpeted, but with an inferior carpet to that provided for the saloon. The lavatory and water-closet doors are made in two leaves to save room, these leaves being connected so that they open and close simultaneously. Beneath the wash-hand basin in the lavatory is fixed an ice safe for the storage of provisions.

The sleeping compartment E is 6 ft. 6 in. long inside, and of course the same width as the saloon, namely 8 ft. 0$\frac{3}{8}$ in. It contains two sleeping couches arranged against the sides of the carriage, as shown in the plan, there being a passage a little over 3 ft. wide between them. The sleeping compartment is trimmed with dark green silk rep, the mattresses of the couches having silk covers, and the curtains being also of dark green silk embroidered with gold. The general finish of this compartment is exceedingly good and in excellent taste, the effect being extremely rich, while, and at the same time, the whole possesses a great air of comfort.

The ventilation of the carriage is secured by providing each compartment with ventilators communicating with air-collecting cowls on the roof, while the vehicle is warmed by Thamm and Rothmüller's heating apparatus, an apparatus which has already been described by us. Altogether the carriage of which we have been speaking is, as we have already stated, very well and conveniently arranged. The workmanship, too, is very fair, although it in some respects lacks the high finish which we are accustomed to find in this country in the productions of our leading firms. It should be stated, however, that the carriage under notice was only ordered on the 11th February, 1873, while it was completed by March 24th, the time occupied in building it being thus only six weeks. This, coupled with the fact that, as we have

already mentioned, it was the first carriage turned out at the Bubna Works, forms sufficient excuse for want of finish in minor points of detail.

Besides the carriage just described, the Bubna Waggons Fabrik also exhibited at Vienna two covered goods wagons of the pattern shown by the views on Plate CXXX., Figs. 4, 5, and 6, one of these wagons being fitted up as a cattle wagon on Dorn's system, while the other—which was exhibited unpainted—was without any special fittings. These wagons are built according to the standard regulations of the Emperor Ferdinand's Northern Railway, and their underframes consist of a pair of wrought-iron sole bars of I-section connected with the timber headstocks by corner and angle irons. The rest of the frame is formed of timber, the cross-bars, longitudinals, and diagonals being arranged as shown in the plan, and connected by tenons and corner irons. The length of the under-frame over headstocks is 6·44 metres (21 ft. 1½ in.) and the width from centre to centre of sole bars 1·918 metres (6 ft. 3½ in.).

The axle boxes are constructed for oil lubrication from the top, the lubricating material being supplied through a wick, and the bearings are composed of a mixture of 50 per cent. of lead, 25 per cent. of good English tin, and 25 per cent. of antimony. The lower part of the axle box is filled with fine shavings of lime wood, which are found preferable to cotton soaked in oil on account of their greater elasticity. The bearing springs consist of plates of cast steel, and have a length from centre to centre of 3 ft. 7 in.; there are nine plates 3 in. wide and ⅜ in. thick.

The hornplates consist of two pieces 2 in. by 2½ in. and ⅞ in. thick; these pieces being bent in such a manner that they can be riveted directly to the inner side of the main soles. The draw-bar is continuous and acts on an india-rubber draw-spring. Screw-coupling and safety chains are provided according to the regulations of the Association of German Railway Engineers. The casings of the buffers are entirely made of wrought iron, and allow of a play of 118 millimetres (4⅝ in.).

The inside length of the body of the wagon is 6·374 metres (20 ft. 7½ in.) and the inside width 2·528 metres (8 ft. 1½ in.). The height in the centre of the wagon is 7 ft. 3⅞ in. The body has four door and four side pillars, besides four corner and end pillars. The door and side pillars are fastened to cast-iron brackets by means of screws and angle pieces, which are carried by the iron main soles. The corner and end pillars are fastened to the headstocks in the usual way, while their tops are, of course, connected to the cant and arch rails. The cant rails consist each of two parts screwed together; the proper or outside rails are made of oak, whilst the inner pieces as well as the arch rails at the ends are of soft wood.

The planking at the side of the body is 1¼ in. thick and consists of pine planks 5½ in. broad. The planking is tongued and grooved, and is fixed to the uprights by two wood screws for each board. The bottom of the body is made of pine battens 1¾ in. thick placed across the wagon and resting upon the main soles and the diagonals, whilst their ends are supported by wrought-iron angle irons, which connect the side brackets with each other and with the headstocks. The bottom planks are tongued and grooved with the exception of the end planks, which are simply rabeted and overlapped and are fastened from below by rails and screws to the angles for the support of the bottom.

At each side the wagon is provided with a sliding door, consisting of a wooden frame strengthened by two diagonal struts, and planked to correspond with the sides of the body. The lifting of the door when shut is prevented by a pin fitting into an eye of the guide rail; this pin is fastened at the lower and left-hand side of the door. The outer support of the guide rail of the door is riveted to the angle iron. In order to use these wagons for the transport of cattle, at the top of each longitudinal side two openings are provided these openings being capable of being closed by flaps.

The roof of the wagon consists of soft wood planking, 6 in. wide and ½ in. thick. These boards, which are placed longitudinally, are rabeted, and lapped over each other, and are carried by the arch rails and the six T-iron roof girders springing from the cant rails. The roof boards are fastened down to

the iron roof girders by means of bars of flat wrought iron and countersunk screws, and the whole roof is covered by plates of thin sheet iron.

As we have already stated, one of the wagons was shown fitted up on Dorn's system, and was provided with hay racks and water troughs, the arrangement being, however, scarcely of a very practical kind. The wagons are carried on Ganz and Co.'s steel disc wheels, and their weight, empty, is 6 tons 1 cwt., their load being given as 10 tons, a load which their large capacity would no doubt enable them to accommodate with average classes of merchandise. The workmanship of the wagons exhibited was excellent.

We have already described a carriage intended for the special service of the Empress of Austria; the next on our list was constructed in 1872 for the use of the Emperor. This is the so-called *jagdwagen*, or hunting carriage, which forms the subject of the engravings on Plate CXXXI., and it was built at the Marburg workshops of the Southern Railway of Austria, from the designs of Mr. John Hardy, the manager of these works, and his son, Mr. J. G. Hardy. As will be seen from the engravings, the vehicle is carried on four of Mansell's wooden disc wheels, and the principal dimensions are as follows :—

	ft.	in.
Length of body over all - - - -	28	$10\frac{1}{2}$
„ „ exclusive of end galleries -	23	$7\frac{1}{4}$
Width of body outside - - - -	9	$3\frac{3}{4}$
„ „ inside - - - -	8	$10\frac{3}{8}$
Height of body inside at centre - - -	7	$4\frac{1}{2}$
„ „ „ sides - - -	6	10
Width of wheel base - - - -	12	$5\frac{5}{8}$

The under-frame is of iron and wood in combination, the soles being of iron of channel section, placed with the flanges outwards, as shown in the transverse section, and the rest of the frame being of timber. The buffer and draw springs are of the ordinary laminated pattern, and the draw-bars are not continuous, an arrangement which we cannot say we like. The continuity of the draw-bar is, however, of less importance in this particular instance, as the carriage we are describing is very generally run at the end of the train, so as to give an uninterrupted view from the hind compartment or *terasse*. The carriage is fitted with a brake applied to both pairs of wheels, this brake being worked from one of the end galleries, as will be seen on reference to the engravings. The brake blocks are of cast iron, and are hung from their centres, while they are kept steady when out of contact with the wheels by springs attached to them, as shown.

The body is made with vertical sides, and it is, as will be seen from the dimensions above given, of unusual width. The body framing is of timber, with the exception of the intermediate side pillars in the end compartment or *terasse*, which are of iron; but the panels are of iron, a material which appears to be now used for panels on the continent to the almost entire exclusion of timber. Referring to the longitudinal and transverse sections, it will be seen that the floor is double, and rests directly on the under-frames, the body being thus principally carried by the floor and the floor framing.

As will be seen from the engravings, Plate CXXXI., access is gained to the carriage by end doors opening to the end galleries, these galleries being made narrower than the width of the carriage, so as to enable steps to be provided on each side without extending beyond the width of the body. The roof extends over the end galleries, being supported by light iron columns, which also form pillars for the neat handrails by which the galleries are protected.

The general arrangement of the interior will be readily understood on reference to the engravings. Commencing at the left hand end of the plan we have first the open gallery, and then a compartment forming a kind of closed verandah or *terasse*, as it is called, 5 ft. 1 in. long. The intermediate side pillars of this compartment are, as we have already mentioned, of iron, while the sash frames at both sides and end are of brass, so as to render it possible to make them of very small dimensions, and thus give a large area of glass with a very small obstruction to the view. This *terasse* thus forms a most pleasant compartment for observing the beautiful scenery traversed by the railway to which the carriage belongs, and we do not wonder that it is a

favourite one with the emperor. The compartment is furnished with a couple of lounging chairs and stools, and is decorated with tapestry work of appropriate design, the decoration of the roof including a picture of the capercailzie, or "cock of the woods," the shooting of which is a favourite sport of the emperor's. The woodwork in this compartment is of old oak.

The next compartment is but 4 ft. 7⅜ in. long inside, and is devoted to the adjutant in attendance on his majesty. The fittings consist of a couch or seat (convertible into a bed), on one side, and washhand-stand (beneath which is arranged a small briquette stove), on the other. The stove just mentioned is constructed on a plan designed and patented by Mr. J. G. Hardy, and of which we shall have to speak presently. The woodwork in this compartment is of oak, and the trimming is of green and black striped silk.

A door swinging either way gives access from the adjutant's compartment to the main saloon devoted to the emperor. This saloon is 9 ft. 4¼ in. long, while the width is 8 ft. 10⅜ in., so that it is really a spacious apartment—spacious, that is to say, for a railway carriage. The decorations of the saloon are in excellent taste, the mouldings being of walnut and ebony, with handsome carvings, while the ceiling is of elaborate parquetry work. The furniture consists, as will be seen from the plan, of an ordinary arm-chair, an arm-chair with a sliding foot-stool, a couch, a table, and a stove on Mr. J. G. Hardy's system, this stove being capped with green marble, and surmounted by a handsome timepiece of appropriate design, as shown in the transverse section. The stove is constructed to burn "briquettes," or blocks of a specially prepared artificial fuel, and it is one which has given excellent practical results.

Continuing our survey of the imperial carriage, we find beyond the emperor's saloon a short passage communicating with an end gallery, sliding doors on each side of this passage respectively giving access to a lavatory and water-closet, and a small compartment intended for the accommodation of the emperor's servant or valet. This compartment also contains a gun rack and an ice safe. From the end gallery adjoining this compartment the brake is worked.

Externally the carriage is painted dark green, relieved by the imperial arms and monograms, &c., in a lighter tint, and picked out with fine gold lines. The general effect is very good, and the carriage is in all parts a thoroughly well finished and most creditable piece of work.

Besides the imperial hunting carriage above described, the Southern Railway Company of Austria exhibited at Vienna a third-class carriage, which, like the vehicle just mentioned, had been built at their works at Marburg. This third-class carriage forms the subject of Plate CXXXII., and its principal dimensions are as follows:

	ft.	in.
Length of body, exclusive of end platforms	22	11⅝
„ „ inclusive „	27	10⅝
„ over buffers	31	2
Width outside	9	4¼
„ inside	8	11
Height „ at centre	6	8⅞
„ „ sides	6	2⅞
Wheel base	13	1½

Number of seats, 48.

Weight empty, 7 tons 15 cwt.

As will be seen from the above dimensions, the carriage is of greater width than can be accommodated on most English lines, and thus, while seating five passengers abreast, space is still obtained for a longitudinal passage from end to end. As will be seen from reference to the engravings on Plate CXXXII., access is obtained to the body by doors opening on to end platforms, these platforms being provided with steps on each side of the carriage, as shown. The body itself is divided into two unequal compartments, the smaller—which contains nineteen seats—being intended for non-smokers. The end doors are placed in the centre of the ends of the carriage, and on each side of them is a seat for two passengers. The remaining seats are

divided unequally, the longitudinal passage being placed out of the centre, so that the seats on one side of it are sufficiently long for three passengers each, while those on the other side accommodate two passengers only. The width of the longitudinal passage is 16½ in., except adjoining the doorway and the intermediate partition, where its width is increased to 18⅞ in. The length of the smaller compartment is 9 ft. 0¼ in., and that of the larger 13 ft. 6½ in., while the seats are 17⅛ in. wide, and the spaces between them 19¾ in. The end platforms are provided with flaps, which fall down to afford communication with the adjoining carriages.

The framing of this carriage forms another example of the composite construction, which we have already mentioned as being so extensively employed in the carriages exhibited at Vienna. The soles are 9¼ in. by 3⅜ in. channel bars, supplied from Seraing, while the rest of the under-framing is of good oak, the body-framing being also of the same material. The soles are placed 5 ft. 11 in. apart, and the body thus overhangs them considerably, as will be seen from the transverse section on Plate CXXXII., and from the enlarged partial section on Plate CXXX., Fig. 7. As in the other Austrian carriages we have already noticed, there are no through tie-bolts, the transverse bearers, which are 6$\frac{11}{16}$ in. by 4 in., resting in angle-iron brackets riveted to the soles, and being secured by being bolted to these angle irons, and by strap bolts as shown. The diagonals, which are 4 in. by 3$\frac{1}{16}$ in., are placed below the cross bearers, and are slightly notched into the latter. Each diagonal extends the whole length of the carriage, from one corner to the other, the two being half-notched into each other at the centre, and strengthened at that point by an iron plate bolted against their under-sides.

The bottom bars of the floor-framing are situated directly over the transverse bearers, and in the case of that at the centre and those at the ends of the body, the portion extending beyond the soles is supported by a wrought-iron bracket riveted to the sole, as shown in the detail view, Fig. 7, Plate CXXX. The body-framing is, as we have said, of oak, while the roof sticks are of beech, and the lining boards, roof boards, and flooring are of pine. The window frames and the cornices are of walnut, stained and polished. The panels are of sheet iron $\frac{1}{16}$ in. thick, supplied by the Prager Eisen Industrie Gesellschaft, the sheets being ground to get a good surface. The roof is covered with zinc, and is provided with copper gutters and wrought-iron discharging pipes for leading off the rain water. By reference to the enlarged section on Plate CXXX., Fig. 7, it will be seen that the cant rails are of such section as to form the hollow for the gutter and also the cornice moulding. The adoption of this section causes these rails to cut into a far larger piece of timber than would be required when the cornice is made in a separate piece, as is usually the case here.

The carriage is lighted by five windows on each side—all these windows being made to open—and by a fixed window in each end door. For night, there are two lamps, one in each compartment. Ventilators are provided over each of the side windows, and those of the seats which come next the ends and the intermediate partitions have boards fixed above them, to take the place of the nets provided in carriages of a higher class. We were glad to see that these boards were provided in several of the third-class carriages at the Vienna Exhibition. In such carriages, both here and abroad, there has generally been a neglect of any provision for small hand baggage, and the boards or shelves form an inexpensive substitute for the nets, and should be generally adopted. In the carriage we are describing, it will be seen that these boards are supported by wrought iron brackets above and below them. The whole support should, however, be given by brackets below, as those above greatly interfere with the accommodation the shelves are intended to provide.

The carriage is mounted on four solid wrought-iron wheels, 3 ft. 3⅜ in. in diameter, both pairs of wheels being fitted with cast-iron break blocks, applied by a screw and hand wheel at one of the end platforms. The wheels are fixed on their axles without keys. The brake blocks, it will be noticed, are hung at the centre of their length, and are kept steady when withdrawn from the wheels by light springs, as shown. The bearings springs are 6 ft. 2⅞ in. long between

centres, while the axle boxes are arranged for oil, the lubrication taking place partly from above and partly from below. The draw-bar is not continuous, the draw-springs being ordinary plate springs, arranged as shown in the plan and half-longitudinal section. The draw-springs, it will be noticed, are held between wrought-iron bars, which connect the transverse bearers. The buffers are shown in the engraving with volute springs; but in the carriage exhibited these springs were of india-rubber, manufactured by the Innerberger Haupt Gewerkschaft, of Leoben. The carriage is throughout very well finished, and for the accommodation it affords it is undoubtedly a very light vehicle.

Amongst the sleeping carriages shown in the Austrian section of the Machinery Hall, one well worthy of notice was that exhibited by the Hernalser Waggon-Fabriks-Actien-Gesellschaft, of Vienna, and illustrated on Plate CXXXIII., Figs. 1 to 7. This carriage is one of four built by the same firm for the Compagnie Internationale de Wagons Lits, and it is intended for service between Paris and Vienna, In designing it the wheels, axles, and running gear have been made in accordance with the regulations of the Empress Elisabeth's Western Railway, while the outline of the carriage in cross section has been made to suit the loading gauge of the Eastern Railway of France. The principal dimensions of the vehicle are as follows:

	ft.	in.
Total length over buffers	28	6
Length of body	25	$3\frac{1}{8}$
Width „ outside	8	$10\frac{3}{8}$
„ „ inside	8	4
Height inside at centre	9	$0\frac{1}{2}$
Total height above rails	13	$5\frac{1}{2}$
Diameter of wheels	3	$4\frac{1}{4}$
Wheel base	13	$5\frac{1}{2}$

Weight, 11 tons 6 cwt.

Referring to the engravings, it will be seen that access to the carriage is given by a single door on each side, these doors opening into a transverse passage which divides the carriage near the middle of its length. On one side of this passage are two compartments intended for gentlemen, each of these compartments containing four seats for day use, or four beds at night. The arrangement of the seats and beds will be seen at once from the engravings, and we need merely add that the upper beds are placed at such a height that even when they are lowered into their horizontal position the seats beneath them can be used if desired.

On the other side of the transverse passage are arranged a lavatory and watercloset as shown in the plan, while between these a central passage leads to the ladies' compartment, this compartment being divided into two by a longitudinal central partition furnished with a sliding door. Each half of the ladies' compartment has a separate entrance door, and each half contains two seats for day use, and two beds for night. The general arrangement is here the same as in the gentlemen's compartment, but owing to having to provide for a passage on each side of the central partition the beds and seats are narrower. Near the lavatory is a press for the linen, and also accommodation for hand luggage, while a box sunk beneath the floor of the carriage, and accessible by a flap opening up in the central passage, affords space for further packages. In the passage flap seats are also furnished for servants or attendants, and pneumatic tubes are provided leading from near these seats to all the compartments. Movable seats and tables are also provided, and at night the vehicle is lit by oil lamps hung from the roof, and by candle lamps on brackets. The heating in winter is effected by Thamm and Rothmüller's apparatus, already described by us, while the raising of the roof in the centre, as shown by the transverse section, affords facilities for good ventilation. Altogether, the carriage is fitted up with every comfort, and it affords accommodation, which will, we think, be appreciated by all who have to make long journeys.

As regards the structural details of the carriage little need be said. The body,—which has iron panels by the way, like most continental carriages,—is

mounted on india-rubber cushion springs, as shown, and is connected to the frame by longitudinal and transverse radius links placed, as shown in Fig. 4, Plate CXXXIII., these links permitting free vertical movement, but preventing end or side motion. The under-frame is of the composite type, with I-iron soles, and the rest of timber. The draw-bar is continuous, and is provided with an india-rubber draw-spring, while the buffer springs are also of india-rubber. The bearing springs are long, being 6 ft. $6\frac{1}{4}$ in. between centres, and each consists of 10 plates 3·54 in. wide by 0·51 in. thick.

As most of our readers are probably aware, two-storied carriages have for many years past been used for local traffic on several of the French railways, and on the Eastern Railway of France in particular there are running some excellent vehicles of this type, constructed on the plans of M. Vidard, of the well-known firm of Bournique and Vidard. This firm was unrepresented at Vienna, but a third-class carriage, constructed on M. Vidard's system, was exhibited by the Hernalser Waggon-Fabriks-Actien-Gesellschaft, of Vienna. This carriage, which forms the subject of the illustrations on Plate CXXXIII., Figs. 7 to 12, is one of eight two-storied vehicles constructed by the makers just mentioned for the Austrian State Railway Company, five of these carriages being composites with first, second, and third class compartments, and without brakes; one being of a similar class, but with a brake; a seventh being all third-class, but without a brake; and the eighth being that lately exhibited at Vienna and now illustrated. As will be seen from the engravings, the vehicle is devoted to third-class passengers throughout, the lower story being divided into five compartments, each holding ten passengers, while the upper story has a similar number of rows of seats, accommodating altogether 40 passengers, the carriage thus carrying 90 passengers in all. The composite carriages above referred to carry each 73 passengers, namely, three first-class in a half compartment or coupé; 16 second-class in two compartments; 14 third-class in one and a half compartments of the lower story, and finally, 40 third-class passengers in the upper story.

In general arrangement, the vehicle we are describing is identical with the French carriages to which we have already referred, but the former is much higher as well as somewhat longer than the latter, the result being that there is a good headway in both the upper and lower stories, a point in which the French double-storied carriages are defective. As in M. Vidard's original carriages, the under-frame is made entirely of iron; and while the head-stocks are kept at the ordinary height from the rails to carry the buffers and draw gear, the intermediate portion of the frame is sunk down so as to enable the floor of the lower story to be kept only 2 ft. $7\frac{1}{2}$ in. from the rails. Each sole or side frame is, as will be seen, formed of two members placed a considerable distance apart vertically, and braced together by the horn-plates and the hangers for carrying the brake shaft. The upper member is of I-section, while the lower one is an inverted ⊥-iron, the two members being united at the ends to the plate-iron curved portions or "swan necks," which carry the headstocks. The latter and the cross-bearers are of channel section.

In the French carriages cast-iron brackets, fixed to the outer sides of the soles, serve to support the bottom sides of the lower body. In the vehicle at present under notice these are dispensed with, the floor of the lower body being strengthened by the employment of transverse bearers of such depth that they stand up above the level of the floor, these bearers receiving the legs by which the seats are carried, as shown in the longitudinal section. The principal dimensions of the vehicle are as follows:—

	ft.	in.
Total length over buffers - - -	29	$6\frac{3}{4}$
Length of body outside - - -	22	$11\frac{5}{8}$
Greatest width of lower story outside -	9	1
" " " inside -	8	$6\frac{3}{4}$
" upper " outside -	8	$4\frac{3}{4}$
" " " inside -	8	0
Length of each compartment of lower story inside - - - -	4	$4\frac{1}{2}$
Length of upper story inside - -	22	6

Extreme height above rail - - -	15	4¼
Clear height of lower story and of upper story at central gangway - - -	6	3½
Diameter of wheels - - - -	2	7·1
Wheel base - - - - -	13	1½

Weight empty, 11·75 tons.

Without a brake the carriages of a similar class weigh 11·1 tons; while the composite two-storied vehicles to which we have already referred weigh 12·15 and 11·5 tons with and without brakes respectively. These weights are very considerably in excess of those of the French two-storied carriages, one of the latter, exhibited at Paris, in 1867, and built by Messrs Bonnefond and Co. on M. Vidard's plans (affording seats for eight first-class, 20 second-class, and 50 third-class passengers, or 78 in all), weighing, empty, only 7¼ tons; while another example of the same system, built by Messrs. Gargan and Co., weighed but 5½ tons, and afforded accommodation for 52 passengers, of which eight were first, 10 second, and the remainder third-class. It must be taken into account, however, that in the French carriages the headway was, as we have already stated, deficient, the clear height of the lower story and of the central gangway of the upper story being 5 ft. 5 in. only, a lowness which was necessitated by the limit placed upon the total height of the carriages by the loading gauges of the lines over which they had to run.

Returning to the carriage which forms the special subject of our notice, it will be seen that access is gained to the lower compartments by ordinary side doors, while the upper story is entered by end doors, to which access is given by iron staircases at each end of the carriage, as shown. The general outline of the carriage in cross section is made to suit the loading gauge of the Austrian State Railways, and its form will be seen from Figs. 7 and 8, Plate CXXXIII. From these, and from the plan, Fig. 11, it will be seen, also, that in the upper story the seats are arranged so as to afford a central gangway, the roof over this gangway being raised, as shown. In the short vertical pieces which unite the raised roof of the gangway with the remainder of the roof of the upper body, are arranged ventilators, as shown in the side elevation and longitudinal sections. The upper roof is supported by the arch rails at the ends and by intermediate rails of light angle iron, and it is composed of planking covered with sheet iron $\frac{1}{20}$ in. thick. The roof of the lower story, which also forms the floor of the upper body, is flat, and is made of pine boarding, 1 in. thick, tongued and grooved, carefully caulked, and covered with india-rubber floor-cloth, so as to prevent any possibility of leakage in the event of any liquid being spilt in the upper story.

The seats, particularly those of the upper story, are very comfortably shaped, and in the lower body rails and nets are provided for hand-baggage; in the upper story there is not room for these rails, but instead, hooks are provided, on which small articles may be hung. As we have already mentioned, the practice of providing accommodation for hand-baggage in third-class carriages is gaining ground on the continent, and we hope to see it become universal. In the carriage under notice both the upper and lower bodies are lit by candle-lamps placed at the ends and fitted with reflectors. Of the remaining details it is unnecessary that we should say much. The wheels are of wrought iron with Bessemer steel tyres and axles, while the axle boxes are on Paget's system, fitted for oil lubrication, but capable of being lubricated with grease if necessary. The bearing springs (which are arranged outside the frames, as shown in the plan) are 4 ft. 5 in. long between end centres, and are each composed of 12 plates 3⅛ in. wide by 0·51 in. thick. The brake is applied to both pairs of wheels, and it is worked by a hand wheel situated at one end of the upper body, as shown.

Altogether, the vehicle we have described is a very good example of a two-storied carriage, and in designing it the desire to keep down the dead weight does not appear to have led to any sacrifice of the strength required for durability. It will be seen, too, that the height available on the Austrian railways affords exceptional facilities for introducing two-storied vehicles which shall be not only economical but comfortable, and there can be no doubt that such carriages will do good service where the traffic requirements

do not necessitate high speeds, and where the stops at stations are sufficiently long to prevent any inconvenience being felt from the less than ordinary accessibility of the upper seats.

The only remaining exhibit of the Hernalser-Waggon-Fabriks-Actien-Gesellschaft which we have to notice here is the small covered goods wagon of which illustrations are given in Figs. 8, 9, and 10, Plate CXXX. This wagon was constructed for the Ebensee-Ischl-Steger Railway, a line of 3 ft. 7·56 in. (3 ft. 6 in. Austrian) gauge now in course of construction along the beautiful valley of the Traun from Ebensee, at the end of the Traunsee, to Ischl; and it is intended for the conveyance of either goods, horses or cattle, or, if necessary, of troops. When used for the latter purpose it will be fitted with benches arranged as shown in one-half of the plan, Fig. 10, these benches being fixed at one end by hooks to the sides of the vehicle; altogether, seats are obtained for 26 men. For carrying horses or cattle, bars are arranged longitudinally and transversely, as shown in the other half of the plan, and accommodation is thus obtained for four animals, while a central passage is left between the two transverse bars. Rings for securing the horses or cattle are of course provided. When employed for the conveyance of goods the wagon is intended to carry a load of 6 tons.

The principal dimensions of the vehicle are as follows:—

	ft.	in.
Length over buffers	19	4·7
„ of body outside	16	3¼
„ „ inside	15	9
Width of body outside	7	1
„ „ inside	6	6·7
Clear height at centre	7	0·6
Height of doorway	6	2·8
Width „	4	7·1
Wheel base	7	2·6
Height of centres of buffers above rails	2	6·3
Distance between centres of buffers	1	7·7
„ „ safety chains	2	11·4
Length of springs	2	7½
Number of plates	8	
Thickness „	0	0·39
Width „	0	3·15
Weight empty	3 tons 5 cwt.	

The wagon has a composite under-frame, the soles being of iron, and the rest of the frame of wood. The draw-bar is continuous and fitted with india-rubber draw-springs; while the buffer-springs are also india-rubber. The buffers, it will be noticed, are placed very close together, their centres being only 0·5 metre (19·7 in.) apart, while the safety chains are arranged outside them. This arrangement of buffers is also adopted on the narrow gauge line between Gmunden and Lambach, one of the oldest railways in Austria, and a line with which that for which the wagon we are describing is intended, may ultimately be connected. The arrangement is, however, inferior in many ways to a central combined buffer and coupling, and it is difficult to understand what originally led to its adoption.

The wagon under notice is close boarded outside the body framing, and it is also boarded inside for about half its height. The roof is covered with sheet-iron 0·02 in. thick. The wheels are all fitted with brakes worked from an outside seat at one end of the wagon, as shown. The workmanship of the wagon exhibited was somewhat rough in some parts; but it was generally good, and the vehicle was altogether a good example of a useful type of narrow gauge rolling stock.

The next carriages we have to notice are those which were shown in the Austrian section by Mr. F. Ringhoffer, of Smichow, near Prague, this maker exhibiting altogether four vehicles, namely, a composite carriage for the Emperor Ferdinand's Northern Railway; a first-class carriage and a boiler van for the Carl Ludwig Railway; and a composite carriage for the Austrian State Railways.

The first of the exhibits just mentioned—namely, the composite carriage for

the Emperor Ferdinand's Northern Railway—is illustrated on Plate CXXXIV., Figs. 1 and 2. From the views there given it will be seen that the vehicle is divided into three compartments, two first class and one second-class, the two first-class communicating with each other, and there being provided in connexion with them, a watercloset and lavatory. The central first-class compartment is of ordinary arrangement, except that on one side the central seat is removed to allow space for a door by which access is gained to a short central passage leading to the other first-class compartment. On either side of this passage are arranged the lavatory and watercloset, as shown in the plan. The end first-class compartment is provided with sleeping accommodation, the two side seats drawing out and being met by frames, carrying suitable mattresses, these frames, when out of use, being folded up into recesses, as shown in the longitudinal section. This end compartment is furnished with the ordinary side doors; but, of course, these are not available when the side seats are arranged as beds, and access to it is then obtained through the central compartment. When the sleeping seats are drawn out the lower parts of the squabs turn over and form pillows, the arrangement being one patented by Herr F. Reifer, of the Emperor Ferdinand's Northern Railway The first-class compartments are trimmed with crimson Utrecht velvet, the upper parts of the sides and the roof being covered with American cloth, and the mouldings being of polished mahogany. Altogether, the two first-class compartments afford, as will be seen, seats for eight passengers.

The second-class compartment presents no special features. It accommodates eight passengers, and the seats are comfortably constructed, the cushions and squabs being covered with green roan.

The carriage we have been describing is 23 ft. 10¼ in. long outside the body and 8 ft. 5·6 in. wide outside above the windows, the width at the bottom being, however, reduced by the great "fall under" given to the sides, to 7 ft. 4 in. The height inside at the centre is about 6 ft. 4½ in. Of the three compartments the end first-class compartment has a length of 6 ft. 1¼ in.; the central compartment a length of 7 ft. 3 in.; and the second-class compartment a length of 6 ft. 0½ in. inside, these lengths being sufficient to give comfortable accommodation.

The wheel base is 14 ft. 6¼ in. and the carriage is mounted on four of Mansell's wooden disc wheels. The bearing springs are a good length, being 6 ft. 2⅝ in. long between end centres, while india-rubber pads also are interposed between the under-frame and body. The under-frame has iron soles of I-section placed 6 ft. 3½ in. apart from centre to centre, while the rest of the frame is of wood. The carriage is fitted with Thamm and Rothmüller's heating apparatus, an apparatus which we have already described, and its weight including this heating apparatus, is 9 tons 9 cwt., the weight without the heating apparatus being about 7 cwt. less.

The arrangement of the carriage we have been describing is, in many respects, a convenient one, and it appears well adapted for use on lines where the nature of the traffic to be accommodated is not such as to create a demand for sleeping carriages properly so-called. The carriage exhibited at Vienna formed part of an order which Mr. Ringhoffer has in course of execution for the Emperor Ferdinand's Northern Railway, and its workmanship was most creditable throughout.

Continuing our account of Mr. F. Ringhoffer's exhibits, we have next to notice the first-class carriage provided with sleeping accommodation, &c., constructed by him for the Carl Ludwig's Railway. This carriage is illustrated on Plate CXXXV., Figs. 1 and 2, and also by Fig. 11 on Plate CXXX. From the plan on Plate CXXXV., it will be seen that the vehicle is divided into three compartments, each provided with the usual side doors; two of the compartments, however, communicate with each other by a central passage, and as they are only divided from each other by a partition reaching about two-thirds of the height of the carriage, as shown in the longitudinal section, they may be considered as practically forming one large or double compartment.

The large double compartment just mentioned is intended for general use, while the smaller or single compartment is reserved for ladies. Between the two compartments is a space set apart for two watercloscts, a diagonal parti-

tion dividing the space as shown in the plan, so that each watercloset is rendered accessible by a central door opening to the corresponding compartment. The arrangement is a convenient one, and occupies little space. The principal dimensions of the carriage are :

	ft.	in.
Length of body outside - - - -	25	$1\frac{3}{4}$
„ „ inside - - - -	24	$7\frac{1}{2}$
Width „ outside above windows - -	8	$5\frac{5}{8}$
„ „ „ at bottom - - -	7	$8\frac{1}{8}$
„ „ inside (mean) - - -	7	$11\frac{3}{8}$
Height inside at centre - - - -	6	$6\frac{1}{2}$
Wheel base - - - - - -	14	$6\frac{1}{4}$

Weight empty, $7\frac{1}{4}$ tons.

As will be seen from the plan the carriage affords seats for 14 passengers, five in the smaller and nine in the larger compartment. In each compartment, also, the side seats can be arranged for beds, as shown in the longitudinal section, the squab of one of each pair of side seats turning over to form a pillow as shown. The arrangement is that to which we have before referred as being patented by Herr F. Reifer, of Vienna. The carriage is trimmed with drab cloth, and the mouldings, &c., are of walnut, the general finish of the interior being excellent.

As regards the structural details of the vehicle there are but few points requiring special notice. The frame is of the composite class with I-iron soles placed 6 ft. $4\frac{1}{4}$ in. apart from centre to centre, the rest of the frame being of wood. The draw-bar is continuous, and the draw and buffer springs are of india-rubber. The bearing springs are of good length, being 6 ft. $2\frac{3}{8}$ in. long between centres, while 10 india-rubber cushion springs are interposed between the frame and body, these springs being carried by external brackets as shown on the side elevation on Plate CXXX., Fig. 11. The body is connected to the frame by radius links as shown. The panels are of iron, and as will be seen from the dimensions above given, the "fall-under" is very great.

The roof is planked both inside and outside the roof sticks, while the floor is likewise planked both above and below the bottom bars, both roof and floor being thus double with enclosed air spaces. The upper planking of the floor is, besides, covered with parquetry. The vehicle is warmed by steam pipes arranged below the seats as shown, the system of heating apparatus being that introduced by Messrs. J. Haag and Co., of Augsburg. The steam is supplied from a boiler in a special van, as we shall describe directly. The ventilation of the carriage is provided for by ventilators over the doors and by a special ventilator in the roof of the large compartment, as shown by the longitudinal section. The carriage is altogether well made and finished.

Another exhibit by Mr. Ringhoffer was the boiler and luggage van which forms the subject of Figs. 3 and 4 on Plate CXXXV. This van, like the carriage last described, is for the Carl Ludwig's Railway, and it contains the boiler from which steam is supplied to the heating pipes already mentioned. The principal dimensions of the van are as follows :—

	ft.	in.
Length over headstocks - -	25	8
„ of body outside - - -	23	7
Width „ „ - - -	8	$8\frac{3}{4}$
Height „ inside at centre -	6	$8\frac{7}{8}$
Wheel base - - - -	14	0
Length of springs between end centres -	3	$7\frac{3}{8}$

Weight, $8\frac{1}{2}$ tons.

As will be seen from the views just referred to, the van consists of three compartments and an open gallery at one end. This gallery, which is protected by an extension of the roof, serves not only as a platform from which the brake can be worked, but it also gives access to the two water-closets contained in the adjoining end compartment. The central compartment is devoted to the steam boiler already mentioned, and it also contains the feed-water tank and fuel bunkers, the arrangement being clearly shown in the illustrations. Just above the boiler the roof is cut away, the lower part of

the chimney being surrounded by a cylindrical casing of sheet iron, having its side perforated as shown. The boiler is mounted on a cast-iron base, which serves as an ash-pit, and it is fed by a suitably arranged pump worked by hand. The boiler communicates with longitudinal pipes placed below the framing as shown, these pipes being coupled to similar pipes below the carriages to be heated by means of india-rubber tubes between the vehicles.

The third compartment of the van is intended for the conveyance of luggage, and it is furnished with sliding side doors as shown. The frame, like that of the carriage last described is of composite construction, and the body which is made without any fall-under, has the framing covered externally with vertical planking. The arrangement of the brake and other details will be understood from the illustrations without any special explanation, and we need only add, therefore, that the workmanship of the van is very good throughout.

The last of Mr. Ringhoffer's exhibits which we have to notice is the composite carriage for the northern district of the Austrian State Railway Company, of which we give engravings on Plate CXXXIV., Figs. 3 and 4. Like the vehicles last noticed, it is a four-wheeled carriage with a "composite" frame, the soles being of **I**-iron, and the rest of the frames of timber. The body is divided into four compartments—two first and two second-class—one of the first-class compartments being a coupé, and being fitted with seats affording sleeping accommodation, as shown in the part longitudinal section.

It will be seen from this view that the end at which the coupé is situated, instead of being made flat as usual, projects outwards below the windows to the extent of $9\frac{3}{8}$ in., a recess being thus formed into which the lower parts of the beds, or extension of the ordinary seats, can be folded. In the plan two of the extensions of the seats or footstools are shown thus folded up, whilst the other is in the horizontal position. The recess also accommodates cushions or pillows for the head.

The coupé accommodates three passengers, and is 5 ft. $3\frac{3}{4}$ in. long inside, exclusive of the recess. The other first-class compartment, which is 7 ft. 2 in. long inside, is fitted up in the ordinary way, and accommodates six passengers; whilst the second-class compartments are each 5 ft. $7\frac{5}{8}$ in. long inside, and accommodate eight passengers each, the total number of persons carried by the vehicle being thus twenty-five. The principal dimensions are as follows:

	ft.	in.
Length of body outside (exclusive of projection at coupé end)	24	$4\frac{1}{2}$
Width of body outside	7	$7\frac{5}{8}$
Height inside at centre	6	$5\frac{1}{4}$
Length over frames	24	7
Distance apart of soles between centres	6	4
Length of bearing springs between centres	6	$2\frac{5}{8}$
Wheel base	14	$6\frac{1}{4}$

Weight empty, $8\frac{3}{4}$ tons.

The first-class compartments are trimmed with crimson Utrecht velvet, and the mouldings, &c., are of walnut and maple. The arms of the seats are made to fold up out of the way when desired. The second-class compartments have the roofs and interior above the cushions lined with oilcloth, while the cushions are covered with leather. The fittings are throughout very neat, and the workmanship is good. The roof, we may add, is double, while the panels are, as in almost all continental carriages, of iron.

The next exhibits we have to notice are those of the Maschinen und Waggon Fabriks Actien Gesellschaft, in Simmering (formerly H. D. Schmid). These consisted of a pair of post-office vans, a saloon carriage, and a sleeping carriage, all of good workmanship. Of the post-office vans we give engravings on Plate CXXXVI., and in Figs. 1 and 2, Plate CXXXVIII., while the sleeping and saloon carriages are illustrated on Plate CXXXVII., and by Figs. 3 and 4, Plate CXXXVIII.

As will be seen from the engravings, one of the post office vans is fitted up as a travelling post office, with complete accommodation for sorting letters,

&c., whilst the other forms a tender, and is constructed to carry the mails in bulk, parcels, &c. The two vehicles communicate by end doors and an intermediate platform protected from the weather by a flexible passage or casing of waterproof canvas. Both the vehicles are of the same dimensions, namely, 21 ft. 9¼ in. long by 8 ft. 9¾ in. wide outside, and 6 ft. 10 in. high inside at the centre. Each also is carried on four wheels placed with a wheel base of 11 ft. 4⅞ in. The frames are also in both cases of the composite type, with wrought-iron soles, and the rest of timber, whilst the wheels are of wrought iron. The two carriages are close coupled, being always intended to be run together, and the tender is fitted with a brake worked from a covered guard's seat provided at one end, as shown in Figs. 5, 6, 7, and 8 of Plate CXXXVI. The weight of the sorting carriage is 9 tons, and of the tender 8½ tons.

Referring to Figs. 2 and 4 of Plate CXXXVI., and to the plan Fig. 1 on Plate CXXXVIII., it will be seen that the sorting carriage has no side doors, and can be entered only by the end door communicating with the other van. It will also be seen from Fig. 4, Plate CXXXVI., that the body is divided by a transverse partition into two unequal compartments, the larger one constituting the travelling post-office, while the smaller, which adjoins the end door, contains on one side a stove, and on the other a lavatory and water-closet. To shut off the latter from the passage, the end door of the vehicle is turned back at right angles, to the position it occupies in the plan, Fig. 1, Plate CXXXVIII., and is secured by a bolt.

The larger compartment of the van of which we are now speaking is admirably fitted up, all the furniture and fittings being in polished oak, and of excellent workmanship. Along the sides and across one end extend tables covered with leather, above which are arranged, as shown, rows of boxes or pigeon holes for the reception of the sorted letters. The interiors of these boxes are covered with green cloth, and underneath each row brass frames are fixed for receiving the names of the various towns to which the boxes correspond. Two rows of these pigeon-holes are intended for letters containing money or valuables, and are fitted with locks and keys. Beneath the tables are drawers and boxes also fitted with locks and keys, and intended for the reception of parcels, whilst beneath the frame of the carriage at the centre of its length is fixed a locker with side doors, in which other parcels can be stowed. The office furniture includes, besides the fittings we have mentioned, three turning stools, a chair, packthread-baskets and knives, hat and coat hooks, luggage carriers, &c., whilst the lighting is effected by two roof lamps, three movable wall lamps provided with pipes for leading off the products of combustion, four branches carrying candles, and three hand candle lamps. The warming is effected by a stove arranged as shown, there being in connexion with the chimney of this stove a contrivance for ventilation on Meissner's system. The ceiling of the carriage is covered with oilcloth, and the floor is of parquetry covered with a carpet of leather.

The other van or tender has, as will be seen from Figs. 7 and 8, Plate CXXXVI., internal fittings of a very simple kind, these consisting merely of shelves for the reception of parcels. It is entered by double side doors, and is provided with the end door already referred to. It is lighted by two roof lamps, whilst beneath the floor at the centre of its length there is arranged a locker with side doors as in the case of the companion vehicle. The side footboards of both carriages, we may add, are fitted with portions which fold back to give access to the lockers. The workmanship of both the vehicles we have been describing is excellent.

Continuing our account of the exhibits of the Maschinen und Waggon Fabriks Actien Gesellschaft, Simmering, we have next to describe the saloon carriage for the administration of the Hungarian State Railways, which forms the subject of Figs. 1 to 4 of Plate CXXXVII., and of which a plan is shown by Fig. 4 on Plate CXXXVIII. Referring to the illustrations, it will be seen that the underframe, which is constructed according to the standard of the Hungarian State Railways, is of the composite type, the soles being of iron, and the rest of timber. The wheel base is 12 ft., and the wheels are all fitted with brake blocks on all sides, these blocks being held between double hangers, and being set forward towards the wheels as wear takes place, by means of

screws acting on plates at their backs, as shown. The brake blocks, we may add, appear to be placed too high on the wheels, and we should anticipate that considerable vibration must take place when the brake is applied. The carriage has outside buffers, and a continuous draw-bar, the draw-springs being volutes.

The body, which has a very slight "fall under" at the sides, projects considerably beyond the soles, and is supported by wrought-iron brackets, as shown in the transverse section Fig. 3, Plate CXXXVII., these brackets having india-rubber pads on their tops. Besides being supported by these brackets, the body rests on the wooden under-frame also. The body is 24 ft. $10\frac{5}{8}$ in. long, by 9 ft. wide outside, and 7 ft. $7\frac{3}{4}$ in. high, and it is, as will be seen from the engravings, divided into an open-sided gallery, a saloon, a lavatory, a water-closet, and a smaller gallery, or end platform, from which the brake can be worked.

The chief gallery or covered platform is 8 ft. $6\frac{3}{8}$ in. long, and is protected by dwarf sides, as shown, the access to it being given by side doors opening inwards. Folding doors at the end also afford the means of communication with the next carriage, the space between the vehicles being spanned by a flap in the usual way, and the folding doors when opened outwards forming the side hand-rails. The roof over the gallery is carried by four columns of neat design, and curtains are provided to afford shelter from the sun and wind. Around the sides and end of the gallery are arranged seats of thin sheet iron pierced so as to imitate canework, while at the end a folding table is provided. The roof of the gallery is lined with American maple with a border of rosewood.

From the gallery access is obtained by a central door to the saloon compartment, which is 13 ft. in length, and which has seats disposed as shown in the plan, Fig. 4, Plate CXXXVIII. As will be seen from the transverse section Fig. 3, and longitudinal section Fig. 4, Plate CXXXVII., the back cushions of these seats are formed by mattresses folded up, and these mattresses when unfolded and laid down convert the seats into very comfortable beds. Beneath the seats are commodious drawers, in which bed-linen, &c., can be stowed. The roof of the saloon is lined in a similar way to that of the open gallery, while the lining of the sides consists of mahogany inlaid with maple and rosewood. The seats are upholstered with silk rep of a warm drab tint, while the curtains are of *gros de Naples* of a similar colour, the whole trimming and ornamentation being done with excellent taste.

A door gives access from the saloon to a small lobby, from which two other doors open, one to the lavatory and the other to the smaller end platform. The lavatory is furnished with a washstand and the usual fittings, while from beneath the washstand a water-closet draws out. Water is supplied from a tank, which can be filled from the roof. The small end platform, to which we have already referred, is protected by dwarf sides, and is provided with side doors opening inwards and with folding doors at the end for giving access to the next carriage. In connexion with the side doors of both the galleries folding foot-steps are provided, as shown.

The carriage is warmed by Thamm and Rothmüller's apparatus, already described by us, and it is lighted by four roof lamps, arranged as shown. In the centre of the roof of the saloon a ventilator is also provided. Altogether the whole of the details of this carriage are well worked out, and are, as we have said, in excellent taste, while the workmanship throughout is of a kind reflecting very great credit on the makers.

The only vehicle shown by the firm of whose exhibits we are now speaking yet remaining to be noticed, is the sleeping carriage represented by Figs. 5 to 8 of Plate CXXXVII., and of which a plan is given on Fig. 3, on Plate CXXXVIII. This carriage affords sleeping accommodation for twelve persons, and its principal dimensions are as follows: Length of body, outside, 25 ft. 11 in.; width of body, outside, 8 ft. $6\frac{3}{8}$ in.; height, 8 ft. $8\frac{3}{8}$ in.; wheel base, 13 ft. $5\frac{7}{8}$ in.; weight $11\frac{1}{2}$ tons. The underframe is of composite construction, and with the running gear, is of the standard type of the Empress Elisabeth's Western Railway. The body is carried on india-rubber cushion springs, and is, as will be seen from the plan (Fig. 3, Plate CXXXVIII.) divided into three compartments besides the lobby, lavatory, and water-closet.

Access is gained to the lobby by side doors; and from the lobby to the several compartments, as shown, the single compartment at one end of the carriage being reserved for ladies, while the two other compartments are for gentlemen.

As will be seen from the various views each compartment contains on each side two seats with a table between them, this table being moveable and the seats being capable of being drawn out so as to meet and form a bed, as shown at the right-hand end of the longitudinal section (Fig. 8, Plate CXXXVII.). The upper parts of the backs of the seats can also be taken out and used as pillows. Above each pair of seats just mentioned is a second bed, which, when out of use, occupies the position shown on the left-hand side of the transverse section Fig. 7, Plate CXXXVII., its underframe then forming part of the ceiling. When required for use each of these upper beds is drawn down into the position shown on the right-hand side of the figure just referred to, it being then 4 ft. 8 in. above the floor, or sufficiently high to clear the heads of people sitting on the seats beneath it, and being supported on suitable fixed ledges. Each upper bed is provided at each end of its frame with a couple of small brass pulleys, over which, and over pulleys fixed to the partitions, as shown in Fig. 7, there passes a suspending cord formed of covered copper wire, this cord being capable of sustaining a load of 6 cwt. The pulley fixed next the side of the carriage is, it will be seen, larger than the others, and it is double, the two ends of the cord passing over it, and being attached to a counterbalance weight running in a suitable casing in the side of the carriage. This weight is such that the bed is perfectly balanced in each position, and it can thus be raised or lowered with great ease, while when closed up it is secured by a lock and key. There is space above each of the upper beds, when raised, to allow of stowing away the mattress, &c., of the lower bed. Curtains are provided for shutting off the beds from the central passage, and there are also small ladders or portable steps for giving convenient access to the upper beds. The lining of the carriage is of mahogany inlaid with rosewood and maple, while the floor is of very well executed parquetry work. The colour of the trimming is a warm drab, the seats being covered with silk rep, and the curtains being of *gros de Naples*.

The roof of the carriage is as will be seen from the transverse sections, raised in the centre, and in this raised portion are hung four lamps provided with ventilating arrangements. The carriage is warmed by Thamm and Rothmüller's apparatus, gratings in the floor admitting the heated air to the body of the vehicle. The fittings of the carriage we have been describing are in very good taste, and the workmanship is excellent throughout. The carriage, we may add, was constructed on the plans of Mr. Georges Nagelmackers, of Liége, and was built to the order of the Compagnie Internationale des Wagons-Lits.

The next vehicle of which we have to speak is a composite carriage constructed by Messrs. Reifert and Co., of Bockenheim, and exhibited in the special pavilion or model station of the North-Western Railway of Austria. The principal dimensions of this carriage are as follows :—

	ft.	in.
Length of body outside - -	22	$10\frac{1}{8}$
Breadth „ „ - -	8	6
Height „ inside - -	6	$9\frac{1}{4}$
Wheel base - - - -	12	$5\frac{3}{4}$
Length of springs between centres -	6	$2\frac{5}{8}$

Weight empty, 8 tons 14 cwt.

The carriage is divided into four compartments, of which two are coupés, and it seats altogether 21 passengers, namely, nine first and 12 second-class. Commencing at one end there is first a first-class coupé 5 ft. long inside and accommodating three passengers, then a first-class compartment 7 ft. 3 in. long inside and containing six seats, then a second-class compartment 5 ft. $10\frac{1}{2}$ in. long inside and seating eight persons, and lastly a second-class coupé, 3 ft. $10\frac{5}{8}$ in. long inside with a single seat for four passengers. In this last coupé by the way, there are no end windows, the seat being placed along the end of the carriage, an arrangement which has an uncomfortable effect. In the first-class compartments the seats draw out so as to meet and form

beds, those in the first-class coupé meeting flaps which fold down from the end. The arrangement is simple and convenient. The first-class compartments are trimmed with scarlet and the second-class with drab plush velvet, and the seats in both classes are tolerably comfortable. The great depth of the cushions, however, leaves no space below the seats for the stowage of small luggage, and the nets above the seats would have been better if made more capacious. The frame of the vehicle of which we have just been speaking is of the composite type, and the panels of the body are, as in all the other carriages exhibited, of iron.

The North-Western Railway Company of Austria also showed in their pavilion two wagons, the one being a covered wagon by the Actien Gesellschaft für fabrikation von Eisenbahn Material, zu Görlitz, and the other a high-sided wagon constructed by Messrs. Klett and Co., of Nuremburg. The former wagon weighed 6 tons 1 cwt., and was intended for a load of 10 tons, while the latter weighed 4 tons 15 cwt., and was rated to carry 11 tons. 5 cwt. Both wagons were fitted with hollow cast-iron disc wheels made by Messrs. Ganz and Co., of Ofen, but in their general construction there was nothing calling for special notice.

The only Austrian railway carriages now remaining to be noticed were two post-office vans, constructed by Mr. Haswell at the works of the Austrian State Railways Company, and exhibited in an annexe at the back of the Machinery Hall, which contained also a large and interesting collection of road vehicles used in connexion with the Austrian postal service. Of the two post-office vans just mentioned, one was remarkable as being the only example of a double-bogie carriage exhibited at Vienna. It had a composite under-frame, the soles being of iron of **I**-section, and the rest of the frame of timber. The bogie frames were of iron, and each bogie had four wheels. Beneath the main frame and between the bogies were iron safes for holding letters or parcels. The other van was a four-wheeled vehicle of ordinary construction, also having a frame of the composite type. Both these vehicles were thoroughly well built.

In the Hungarian section of the Machinery Hall the chief exhibit in the class with which we are now dealing, was an admirably built saloon carriage, constructed by the Erste Ungarische Waggon-Fabrik-Actien-Gesellschaft, of Pesth, for the use of the Hungarian Ministry. This carriage had a platform at one end, to which access was gained by folding steps, a door opening from this platform to the main compartment or saloon, which occupied about half the length of the vehicle. From this saloon a door at the end furthest from the platform and close to one side of the vehicle opened to a kind of lobby, from which access was gained to a lavatory and water-closet, whilst beyond was a smaller compartment entered from the lobby by a central door and containing a couple of beds. The saloon contained a central table and a seat extending along one side and partly across the ends, the trimming being of brownish purple morocco, with rep curtains to match, while the sleeping compartment was trimmed with grey drab rep, and provided with velvet curtains of a similar colour, lined with silk. The internal fittings were of satin-wood with mahogany mouldings, and the whole of the ornamentation was in excellent taste. The carriage was heated by Thamm and Rothmüller's apparatus already described.

The underframe of the vehicle under notice was of timber, the soles, however, being strengthened by wrought-iron plates bolted to their outer sides. The arrangement of the spring gear was somewhat peculiar. To the outer side of the sole were attached neatly designed wrought-iron brackets, which extended downwards, and then curved inwards so that the lower end of each was directly below the end of a bearing spring. From the lower ends of these brackets long vertical spring links extended upwards to the springs, these links being so jointed to the brackets at their lower ends as to be free to swing both longitudinally and transversely. The axle guards also were constructed so as to allow play to the axle boxes, and the carriage was thus hung upon the springs in a way which gave great freedom of movement, and which we understand has been found to give satisfactory results. The car-

riage was of very good workmanship, and was exceedingly well finished in all its details. Its cost is said to have been 12,000 florins, or about 1,090*l.*

The same makers were also the exhibitors of a well made covered goods wagon with a composite under-frame, and the body, as is usual in continental wagons, planked outside the framing. There was nothing about the wagon requiring special description here, but we may mention that it was mounted on solid disc wheels by Ganz and Co., of Ofen, that it weighed 6 tons 6 cwt. empty, and that it was intended to carry a load of 10 tons, or to be employed in transporting 36 men, or six horses.

The remaining Hungarian exhibit of rolling stock was a third-class carriage constructed at the works of the Hungarian State Railways at Pesth. This was a four-compartment carriage mounted on four wheels and furnished with an outside covered seat for the guard at one end. The brake worked from this seat was applied to both pairs of wheels, a lever on a brake shaft at the end of the vehicle being connected by links to a couple of brake shafts carried by the brake block backs. The carriage seated 40 passengers, and the backs of the seats were marked by lines showing the space allotted to each passenger. Boards carried by standards from the dwarf backs of the seats were provided instead of nets for the accommodation of hand luggage,—an arrangement well worthy of imitation in our third-class carriages in this country. The under-frame was of composite construction, the soles being of iron and the rest of the frame of timber. The panels were of iron, and the workmanship throughout was very good, without any unnecessary finish. The weight of the carriage was 8 tons 12 cwt.

Before leaving the Austrian and Hungarian sections there are a few exhibits of rolling stock details requiring notice. Thus Egan's disc springs, illustrated on Plate CXXXVIII., Figs. 5 to 11, were shown in various forms, and arranged for application as either buffer, draw, or bearing springs. Mr. Alfred Egan is the engineer of the Theiss Railway, Hungary, and his springs consist of a number of discs each stamped in dies so as to give it a concave form, and at the same time to give it annular corrugations. Figs. 5, 6, and 7 of the views on Plate CXXXVIII. show several sections of these discs, and the manner in which the latter can be applied is clearly shown by the other figures. We may remark, however, that it is not in all cases necessary to string the discs on a central rod, as they can be enclosed by a casing or between suitable guides. The discs may also be made of varying thickness, as, for instance, in Fig. 7, where they are thinned out towards the centre to augment the elasticity. The discs of such springs, as at present already in use under railway wagons, are about 8 in. in diameter. According to another plan the elasticity of the discs is heightened by rendering the several sets air-tight at the edges and forcing compressed air into them.

It will be seen from the description we have given, that Mr. Egan's springs belong to the same class as the Belleville disc springs and the disc springs tried many years ago by Mr. William Bridges Adams. They possess, however, the distinctive feature of the annular corrugations; but in the absence of detailed particulars of the powers of resistance and elasticity of the springs, we cannot speak as to the influence of this feature. We understand, however, that a number of the springs are in use on Austrian railways, and that they have stood severe tests satisfactorily. Their form evidently renders it possible to manufacture them at a very moderate cost, and the operation of changing or replacing the discs is very readily performed.

Messrs. Ganz, of Ofen, and the Dernö Iron Works, of Count Adrassy, near Rosenau, Hungary, were exhibitors of chilled cast-iron wheels. The wheels of the latter makers are shown by Figs. 12 and 16 on Plate CXXXVIII., Fig. 12 representing a 3 ft. wheel for railway wagons, and Fig. 16 a 21 in. wheel for trolleys, &c. From these views it will be seen that the wheels are of the double web type, the tread of the tyre being strengthened by transverse internal ribs. Since 1864, 22,000 chilled wheels have been turned out at the Dernö Iron Works, and after careful testing by the Hungarian Government, these wheels are now used on the state railways, the supplying of which was formerly a monopoly in the hands of Messrs. Ganz and Co.

The wheels exhibited by Messrs. Ganz and Co. were of various types, and illustrated the changes which have been made since the construction of such wheels was first undertaken by the firm. From these exhibits it appeared that the earlier wheels were all of the double web form, but that gradually this was replaced by preferable sections, the standard type made by Messrs. Ganz, when they have their own choice in the matter, being now that shown by Fig. 13, Plate CXXXVIII. Some railways, however, still use the double web type, shown by Fig. 15, while others, and amongst them the Empress Elisabeth's Western Railway, of Austria, prefer an intermediate pattern, shown by Fig. 14, Plate CXXXVIII., the web in this case being double for a short distance from the boss, and then merging into a single web, as shown. Tests made with a falling weight striking the wheels on the tread of the tyres (the wheels standing up edgeways) show that the patterns with the single web have at least equal power of resistance with those having double webs, while the manufacture of the former is, of course, a more simple operation. When tested by the falling weight the double web wheels generally fail by circumferential cracking in the tread, whilst the single web wheels indicate their failure by radial cracks in the web itself. We have had an opportunity of examining the accounts of official tests of Messrs. Ganz's wheels, and the uniformity of the results obtained speaks most highly as to the care and skill exercised in their manufacture.

Amongst the details shown in the Austrian section we have also to include a somewhat novel construction of chilled cast-iron railway wheels with wrought-iron spokes, of which a pair were exhibited at Vienna, from Mr. C. I. Bergmann's foundry and iron works, of Graz, Styria. These wheels, which have been designed and patented by Mr. Ludwig, the manager of the above works, are intended as substitutes for the chilled cast-iron disc wheels in use to some extent on Austrian and German railways, and their construction will be readily understood from the engraving on Plate CXLI, Figs. 4, 5, and 6. The rim is cast in a chill, and from its form it can, without risk, be cast of harder iron than is usually employed. The rim and boss are connected by wrought-iron spokes as shown, and the wheel is stated to be capable of being broken only with great difficulty. One hundred and sixty pairs of these wheels had in 1873 already been running about a year on the Graz-Koflacher Railway, and they are stated to have given good results.

Russia.

In the Russian section we found three exhibits of rolling stock, namely, a sleeping carriage, a third-class carriage, and an open goods wagon, all of course constructed for the Russian 5 ft. gauge. The sleeping carriage was a long and very wide six-wheeled vehicle, having two end platforms from which access was gained to the interior. Entering from one of the platforms there came first a small saloon compartment fitted up with a table, couches, and couple of chairs, next a kind of transverse lobby containing on one side a stove, and on the other a water-closet, and next two sleeping compartments, the passage through these being on one side of the centre. In each of these last-mentioned compartments there were on one side of the passage a couple of beds—one above the other—arranged longitudinally, and on the other side four beds (in two tiers) arranged transversely, there being thus twelve beds in all. For day use the upper beds can be stowed away, and the lower beds converted into seats for twelve passengers. The upper beds, we should mention, are formed by turning up the backs of the seats. The carriage was trimmed with red plush, the seats in the saloon being edged with silver and scarlet lace. The various compartments were divided by sliding doors veneered with walnut. The carriage was rather dark, and the means for ventilation appeared very deficient.

The Russian third-class carriage was also a six-wheeled vehicle with end doors, there being a platform at one end. Of the details of this carriage there is nothing much to be said, but we may remark that provision was made for hand baggage, wooden rails being provided in place of the nets fitted to vehicles of a higher class. Both the Russian carriages had composite frames

and iron panels, and the workmanship was very fair, but of rather rough finish. The goods wagon in the Russian section was one constructed by Messrs. Lilpop, Rau, and Co., of Warsaw. It was a low-sided wagon with iron frame and iron side pillars, and was provided with both side and end doors. At one end was fixed a seat for a brakesman, the brake, which was applied to all the wheels, being of somewhat complicated construction. The details of this wagon were well proportioned, and the workmanship very good.

Germany.

The exhibits of railway rolling stock by German makers were displayed, some in the Machinery Hall, some in a special annexe at the back of the Machinery Hall, and the rest in the department containing what was termed the sanitary exhibition, or that devoted to "ambulances and other appliances " for the accommodation and treatment of the wounded during war." In the first place we shall speak of the exhibits in the Machinery Hall, these being only a very well-built carriage by the Frankfurter Waggon-Fabrik, formerly J. and C. Reifert and Co., and the other being an accident van and crane constructed by Van der Zypen and Charlier, of Deutz.

Of the former vehicle, which was constructed for the Mittau Railway, a short line extending from Mittau to Riga, we give views on Plates CXXXIX., CXL, and Fig. 7, Plate CXLI. The carriage is built to suit the standard Russian, or 5 ft. gauge, and, as will be seen from the illustrations, it is carried on six wheels, the total wheel base being 20 ft. The total length of the body outside is 32 ft., and the width outside 9 ft. 10 in., while the clear height, inside at the centre, is 6 ft. 10 in., and at the side 6 ft. 5 in.

The underframe is entirely of iron, and its construction is shown clearly by the plan on Plate CXXXIX. and by the transverse sections on Plate CXL. From these views, and from the side elevation, it will be seen that there project from the outer sides of the soles, wrought-iron brackets carrying reversed springs, upon the centres of which the body rests. There are, as will be seen, six of these reversed springs—three on each side—their length being equal to that of the ordinary bearing springs, but they having of course a less number of plates than the latter. The strain put on the projecting brackets by the longitudinal pull of these springs is, as will be seen, resisted by tie-bolts connecting the end brackets to the headstocks, and the intermediate brackets with each other.

Besides being connected to the reverse springs just mentioned, the body is tied down to the underframe by links at each corner, these links being attached to bolts, which pass down through brackets fixed to the underframe, each having at its lower end a nut bearing upon a thick india-rubber washer interposed between it and the under-side of the bracket. By this arrangement the recoil of the intermediate or body springs, as they may be termed, is limited. The end play of the body on the underframe is prevented by brackets fixed to the under side of the body near the corners, these brackets extending downwards at a short distance inside the headstocks, and there being interposed between them and the latter india-rubber washers or pads, as shown in the side elevation on Plate CXL. The system of carrying the body of a railway carriage on reversed springs interposed between it and the underframe in the manner above described is one introduced by Mr. Reifert, and it has been found to give very good results as far as easy [illegible]iding is concerned. Its employment, however, undoubtedly adds materially [illegible] the cost of a carriage, and also increases to some extent the proportion [illegible]lead weight to paying load. In the case of saloon or sleeping carriages [illegible]sly designed to afford luxurious accommodation, these objections, [illegible] become of secondary importance.

[illegible]r now to the internal arrangements of the vehicle of which we are [illegible]t will be seen from the sectional plan on Plate CXL. that access [illegible]or is obtained by side doors situated close to each end of the [illegible]e doors opening to transverse end lobbies or covered platforms. [illegible]s a central door at each end of the carriage, while folding flaps [illegible]ive access to the adjoining vehicles. From one of the end

galleries—that on the left-hand side of the plan—three doors open besides those just mentioned. Of these three doors, the first gives access to a lavatory and watercloset, the next to a small compartment containing a stove, and the third to a longitudinal passage which extends along one side of the carriage for half the length of the vehicle between the end galleries. From this longitudinal passage access is gained to two compartments, one containing three and the other six seats, as shown. In the six-seated compartment the opposite seats can be drawn out to meet, as represented in the longitudinal section on Plate CXXXIX., and the lower squabs on one side being then turned over and slid down, as shown, three comfortable couches or beds are formed. By turning up the arms of the seats, sleeping accommodation is also afforded in the three-seated compartment.

At the end of the longitudinal passage already mentioned is a door leading to a kind of double compartment, to which access is also afforded by a door opening to the adjoining end gallery. This double compartment contains 11 seats, the arrangement of which will be at once seen on reference to the plan Fig. 2, Plate CXL. Eight of these seats are disposed in pairs opposite each other, and each pair of opposite seats is convertible into a couch or bed in the same manner as those in the six-seated compartment already spoken of. The remaining three seats are provided with leg rests, which can be drawn out and arranged, as shown at the right-hand end of Plate CXXXIX.

In one corner of the double compartment just mentioned is placed a stove, this stove being shielded by a sheet-iron casing of considerably larger diameter, as shown in the longitudinal section and sectional plan. The smaller compartments are heated from the other stove previously mentioned, and to afford greater protection against cold the floor, roof, and transverse partitions are made double, while cushions are provided, which can, when desired, be placed over the fixed windows.

Ventilation is provided for by sliding ventilators above the windows, and by ventilating cowls on the roof, while, as is usual in Russia, the carriage is lit by lamps arranged in or against the partitions, stearine candles being burnt in these lamps, and the chimneys passing up through the roof. The compartments of the carriage are trimmed with red-brown plush, and the passages, lavatory, and end galleries, with a brownish grey cloth and plush. The doors, frames, and internal mouldings generally are of polished mahogany. Commodious nettings are provided for hand-baggage, and the internal fittings generally are very good.

The carriage is provided with a continuous draw-bar and volute draw-spring, while the buffer-springs are also volutes. The manner in which the latter are arranged is shown by the detail views on Plate CXLI., Fig. 8, each buffer having two springs placed as shown, and that inside the headstock not coming into play until the outer spring has undergone some compression. The arrangement is a good one, but costly. The wheels of the carriage are solid wrought iron, and the axle-boxes are arranged for oil lubrication. The whole of the details of the carriage are well designed, and the workmanship is of high character throughout.

The accident van and crane constructed by Messrs. Van der Zÿen and Charlier, of Deutz, already mentioned, is illustrated on Plate CXLI., Figs. 1, 2 and 3, and it is, as will be seen, conveniently arranged, the only objection to it being that the van portion blocks the crane in one direction. The vehicle consists of a very strong wrought-iron frame 25 ft. $4\frac{3}{4}$ in. in length, carried upon four wheels arranged with a wheel base of 15 ft. $11\frac{1}{2}$ in., there being mounted on this frame directly over one of the axles a powerful crane capable of lifting loads of $2\frac{1}{2}$ tons. The jib of this crane is of the box-girder type, and it has a radius of 11 ft. $10\frac{1}{8}$ in., while its form is such as to give a good clear headway under it for lifting bulky loads. The arrangement of the hoisting gear will be seen from our engravings; but this arrangement might, we think, have been improved by placing the chain drum at the back of the jib instead of underneath it, as shown. If this had been done the chain could easily have been kept clear of the crane post, and the jib would have been relieved of the strain at present brought upon it by the tension of the chain. The crane post is of cast iron, and the weight of the crane with its load is carried by a centre at

the upper end of the post, as shown. When out of use the crane is swung round to the position shown in the side elevation and plan, and secured by a locking screw, which can be screwed down into a corresponding socket on the frame of the van.

Besides the crane there is mounted on the underframe a small body containing accommodation for a brakesman, and for the gang of men working the crane, while beneath the frame is a large tool box, as shown. The body of the van contains a bench with a vice, &c., while the tool boxes contain lifting jacks, and all necessary tools and appliances for use at a breakdown. One pair of wheels is fitted with a brake, while appliances for securing the vehicle to the rails when the crane is in use are also provided. As we have said the general arrangement is a convenient one, but the vehicle would be of much greater use at most accidents if the crane was more powerful, and could swing a load all round.

We have now to examine the collection of German railway carriages and wagons which we have already mentioned as being exhibited in an open-sided annexe at the back of the Machinery Hall, and we shall in the first place speak of the carriages shown by Mr. Joseph Rathgeber, of Munich. One of these carriages was of very remarkable design, and it is with that we shall deal first.

The carriage in question was one intended for the Associated Swiss Railways, and it was constructed by Mr. Rathgeber upon the designs of Mr. A. Klose, the locomotive superintendent of those lines. Its arrangement and chief peculiarities of detail are shown by Plate CXLII., and by the additional views on Plate CXLIII., Figs. 7, 8, and 9. Referring to the plan on Plate CXLII., it will be seen that the body is divided into three passenger compartments, the central compartment extending the full width of the vehicle, whilst the two end compartments are narrower, space being thus left on one side of each of these latter compartments for an open gallery, and these two galleries being, as will be seen, situated on opposite sides of the vehicle. At the ends of the carriage are transverse platforms protected by hand-rails, as shown by the side and end elevations on Plate CXLIII., Figs. 7 and 8; these views, together with the plan, Fig. 9, on the same Plate and the plan on Plate CXLII., also explaining the arrangement of the steps by which access is gained to the end platforms and side galleries.

The central compartment, which is entered through doors at the ends of the side galleries, is fitted up as a saloon, and is provided with tables, settees, and movable stools. Mirrors are placed at the ends, as shown in the transverse section on Plate CXLII., and the decorations generally are in very good taste. The trimming of this compartment is of sage green silk.

Of the two end compartments the one contains six and the other three first-class seats, the size of the latter compartment having been reduced to make room for the lavatory and watercloset, which are arranged as shown in the plan on Plate CXLII. The lavatory is, as will be seen, entered from the saloon, and the watercloset from the adjoining side gallery. The six-seated end compartment is entered from the adjoining side gallery, and the three-seated compartment from the corresponding end platform, while both compartments are luxuriously fitted up, the former being trimmed with drab and the latter with blue silk.

The framing of the body is of composite construction, some portions being of timber, while the side pillars and sash frames are of iron. The side pillars are riveted to a longitudinal T-iron fixed to wrought-iron brackets, which project from the outer side of the soles. The flooring of the carriage is heavy, it consisting of 2-in. planking, but this planking only extends the full width of the vehicle for the length of the central compartment, its width at other parts being that of the end compartments only, and the side galleries being floored with chequered plates. This arrangement is shown by the lower transverse section on Plate CXLII. The panels are, as usual on the continent, of iron. The roof is, as will be noticed, raised along the centre, the width of this raised portion being only half as great over the end compartments as it is over the saloon.

The underframe is entirely of iron, and its construction is somewhat peculiar, as will be seen on reference to the plan, Fig. 9, Plate CXLIII. The soles, it will be noticed, are cranked inwards at their ends to afford room for the footsteps, and in consequence of this, combined with the fact that the diagonals spring nearly from the centre of the length of the frame, the latter is not well stayed cornerways, and appears liable to become distorted by buffing strains. The iron foot plating of the end platforms may, however, if firmly attached to the underframe, serve to prevent this to some extent. The carriage is fitted with a continuous draw-bar and volute draw-springs, while the safety chains also pull against volutes, and the pair of short draw-bars at each end, to which the safety chains are attached, are connected by bell cranks and a coupling bar, the arrangement being intended to equalise the pull brought upon the two chains.

One of the chief features in the carriage is the arrangement adopted with a view of causing the axles to radiate when the vehicle is traversing curves. This arrangement is shown by the elevation and plan, Figs. 8 and 9, Plate CXLIII. The axle-boxes are free in the horn-plates, and the bearing springs, instead of having their ends attached direct to the underframe, are coupled to the centres of short vertical levers, of which the lower ends are jointed to brackets fixed to the underframe, while the upper ends are connected by coupling bars. Beneath the under-frame are arranged two transverse levers working on centres, and having a length about equal to the distance between the centres of the soles, and these levers, in addition to being coupled to each other by diagonal links extending from the right-hand end of one lever to the left-hand end of the other, and *vice versâ*, are also connected at their ends with the upper ends of the adjoining short vertical levers, which we have already mentioned as receiving the pull of the bearing springs. Owing to the carriage being, as it were, slung on the short vertical levers, to which the bearing springs are attached, the tendency is for these levers, to maintain their vertical position the two axles being, at the same time, parallel to each other. It follows, however, from the arrangement of the transverse levers and diagonal coupling links, that if the ends of the two axles are drawn together on one side of the carriage they will be correspondingly forced apart on the other side, and they may thus be made to assume positions radial to curves which the carriage may be traversing. Although, however, the radial adjustment is thus rendered possible, it is by no means clear by what influence the radiating action is to be caused. When a four-wheeled carriage enters a curve the flanges of the leading outer wheel and the inner trailing wheel strike the rails and the extra resistance thus opposed to these two wheels would, it appears to us, with the arrangement above described, tend to produce a movement of the axles the reverse of radiating. On the Paris, Sceaux, and Orsay Railway a somewhat similar arrangement of diagonal links was at one time—and, in fact, we believe still is—employed to cause the radiation of axles of four-wheeled carriages, but in that case the radiating action was determined by a longitudinal arm projecting from one of the transverse levers, this arm being coupled to the next vehicle, which by its position pulled the arm to one side, and thus brought the diagonal links into operation. Without this or some equivalent contrivance to determine its action the arrangement of transverse levers and diagonal links appears to us to be—to say the least of it—of very doubtful utility.

The general workmanship of the carriage we have been describing was very good, and the finish of many of the details particularly neat. The dimensions are given on our engravings in metrical measures; but for convenience we subjoin a table of the principal ones in English feet and inches. The carriage is, as will be seen, of unusual width.

	ft.	in.
Length over buffers - - - - -	31	$2\frac{3}{8}$
„ underframe - - - -	28	8
Breadth over end platforms - - - -	9	$6\frac{1}{8}$
Distance between centres of soles for the main part of their length - - - - -	6	$0\frac{7}{16}$
Distance between centres of soles at ends - -	4	$5\frac{9}{16}$
Length of body exclusive of end platforms - -	24	$0\frac{1}{2}$

	ft.	in.
Width of body outside	9	10⅛
„ „ over cornices (extreme)	10	2
„ of saloon inside	9	5
Length of saloon inside	9	7¾
„ of three-seated end compartment inside	4	5
„ of six-seated „ „ „	6	9⅞
Width of end compartments inside	6	11½
Length of lavatory and water-closet	3	4¾
Width „ „	2	3⅛
Height of body inside at centre	8	1¼
„ „ sides	6	10⅝
„ of doorways	6	4⅞
Clear width of doorways to saloon	1	11⅝
Diameter of wheels	3	5
Wheel base	14	9⅛

Besides the carriage above described Mr. Rathgeber also exhibited at Vienna a composite carriage for the Emperor Ferdinand's Northern Railway, this vehicle forming the subject of the engravings on Plate CXLIV., From the views there given it will be seen that the carriage contains two first-class and two second-class compartments, one compartment of each class being single and the other double seated. The carriage thus affords seats for nine first and twelve second-class passengers, or twenty-one in all, while the single-seated first-class compartment is a *damen coupé*, or reserved for ladies' use. The principal dimensions of the carriage are as follows:—

	ft.	in.
Length of body outside	23	10
Width „ „	8	5 9/16
„ „ inside	7	11 7/16
Amount of "fall-under"	0	6¾
Length of two-seated first-class compartment inside	7	1
Length of ladies' compartment inside	4	9 7/16
„ two-seated second-class compartment inside	5	10½
Length of single-seated second-class compartment inside	4	3⅞
Height of carriage inside at centre	6	5
„ „ sides	6	2½
Distance apart of soles from centre to centre	6	3½
Depth of soles	0	9⅜
Diameter of wheels	3	2⅝
Wheel base	14	6¼

Weight empty, 10 tons 11 cwt.

As will be seen from the engraving on Plate CXLIV., the frame of the carriage under notice is of the composite type now so popular on the continent. The wheels are of the Mansell wooden disc pattern, and india-rubber pads are interposed between the underframe and body. The first-class compartments are trimmed with crimson plush velvet, and are arranged to afford sleeping accommodation, the seats of the larger drawing out, as shown by the plan, and the dotted lines in the longitudinal section, while in the smaller or ladies' compartment the seats also draw out, and are met by feet rests, which, when not in use, fold up against the partition as shown. The second-class compartments are well trimmed with green leather, and comfortably cushioned, while in all the compartments are curtains and good-sized nets for hand baggage. The fittings are altogether very good, and the carriage is throughout well built.

Messrs. Carl Weyer and Co., of Düsseldorf, exhibited a covered goods wagon fitted with Sarth's coupling, it being the 2,300th wagon of this type constructed by the makers for the Cologne-Minden Railway. Zürth's coupling consists of a pair of links hinged to the headstock, one on each side of the draw-hook, these links inclining towards each other, and carrying between

them at their outer ends a second draw-hook. The underframe of this wagon was all iron, but the body framing is of timber, the planking being inside the pillars, as is generally the case with wagons made in this country, instead of outside, as is more usual in Germany. The wagon was fitted with a brake applied to all the wheels, this brake being worked from an outside seat provided at one end. The buffer and draw-springs were volutes, and the draw-bar was continuous. The weight of the wagon empty was 7 tons 4 cwt., and it was intended for carrying 10 tons of goods, or 32 men or 6 horses. The wagon was of a useful type, and well made.

The Schlesische Actien Gesellschaft (formerly Schmidt and Co.), of Breslau, were the exhibitors of three coal wagons, which were characterised by some features worthy of special notice. Of these the first was first was a high-sided wagon made entirely of iron, the under-frame consisting only of the soles, longitudinals, headstocks, and two transverse bearers, there being no diagonals. The floor was riveted to the frames, and the bottom plates were dished upwards thus —⌒— in the centre. There were no end pillars to the body, but stiffness was obtained by cranking the end plates, so that their horizontal section was thus —⌐¬—. The buffer and draw-springs were volutes, and the draw-bar was continuous, while the buffers had skeleton cases. Although intended to carry loads of 15 tons, the weight of this wagon was but 5 tons 3 cwt., yet it appeared to be quite strong enough for its work.

The second wagon was of similar construction to that just noticed, save that the ends were flat instead of being cranked inwards at the centre. A perspective view of this wagon is given on Plate CXLV., from which it will be seen that there are no side pillars except just at the sides of the side doorways. The wagon is fitted with a brake, as shown, and that at the Exhibition had Krupp's cast steel disc wheels instead of the wrought-iron spoke wheels shown in the illustration. The weight of this wagon was 5 tons 3 cwt., and it was intended to carry a load of 13 tons 4 cwt. The third wagon shown by Schlesische Actien Gesellschaft, was, like the others, entirely of iron, and it was one constructed for the Upper Silesian Railway. The body was stiffened at the sides by T-iron standards, and by a channel iron riveted around the upper edge. The bottom plate of the wagon was riveted to the headstocks. The weight of this wagon was 4 tons 19 cwt., and it was intended for loads of 11 tons.

A coal wagon made entirely of iron, was also exhibited by Messrs. Ruffer and Co., of Piela. This was a high-sided wagon with side pillars of T and I iron, and presented no special feature requiring notice. The weight and load of this wagon were not given, but it appeared rather heavy.

We have next to notice the exhibits of the Breslauer Actien Gesellschaft für Eisenbahn Waggonbau, these consisting of the composite carriage and covered goods wagon, which form the subjects of Figs. 1 to 6, Plate CXLIII., and of Figs. 2, 3, and 4, Plates CXLV. respectively.

The carriage, which we shall first describe, is 30 ft. 10 in. long by 8 ft. $6\frac{3}{8}$ in. wide outside the body, and is carried on four wheels, the wheel base being very long, namely, 16 ft. $4\frac{3}{4}$ in. The underframe is entirely of iron, and between it and the body are interposed steel auxiliary springs, as shown in Figs. 1 and 3, Plate CXLIII. These auxiliary springs are 2 ft. $7\frac{1}{2}$ in. long between end centres, and there are four of them on each side of the carriage. They are placed directly over the soles upon which they bear, and their ends are coupled by links to angle irons, of which a pair extends longitudinally under the body on each side for its whole length. The auxiliary springs lie between the angle irons, as shown in the transverse section. The attachment of the auxiliary springs is also shown by the detail view given in Fig. 4, Plate CXLIII. Radius links, situated at the four corners of the body, and pulling against india-rubber pads, as shown in the side elevation and transverse section, prevent any end motion of the body on the underframe, while too great freedom vertically is prevented by leather straps attached to the corners of the body and connecting the latter to pins, pulling against very thick india-rubber rings, which have a bearing against brackets fixed to the underframe. This arrangement of check spring is shown by the side

elevation and transverse sections, Figs. 1 and 3, and also by the detail transverse section, Fig. 4, Plate CXLIII. The draw-bar is continuous, and the buffer and draw-springs are volutes, while the buffers have wrought-iron skeleton casings.

The panels are of iron, and besides being stiffened by the longitudinal angle irons already mentioned, the body frame has bottom cross-bars of ⊥-iron filled in with wood, alternating with cross-bars of wood only, as shown by Figs. 1 and 6, Plate CXLIII. The roof and floor are double, and the doors have strips of india-rubber let into dove-tail grooves in their framing; these strips closing against similar strips let into the body framing, as shown in the detail views Figs. 4 and 5, Plate CXLIII. Fig. 4, just referred to, also shows the arrangement of counterweight provided for balancing the window sashes of the doors, the counterweights being connected to a bar on which the sash rests, when partially open or being lowered, and this bar serving also when in its highest position to close the "well" in which the sash runs. The standing pillars are furnished with the finger guards very generally used in German railways, these guards each consisting of a strip of stiff leather fixed so as to overlap the joints, as shown in the detail section, Fig. 5, Plate CXLIII. Fig. 3, on the same Plate, shows the ventilators over the fixed side lights.

Referring now to Figs. 1, 2, and 3, Plate CXLIII., it will be seen that the body is divided into two double compartments, having between them a central space, which is divided by a diagonal partition (as shown in the plan) so as to form two unequally sized lavatories, each containing a watercloset; these lavatories communicating one with each of the double compartments already mentioned. Of the two double compartments, one is first and the other second class, the former carrying 12 and the latter 14 passengers. The arrangement of the seats will be readily understood from the sectional plan, from which it will be seen that the two parts of each double compartment are separated by a half partition with a communicating gangway, the gangway in the first-class compartment being central, while in the second-class compartment it is placed out of the centre, so that double seats are obtained on one side of it.

The first-class compartment is trimmed with green Utrecht velvet, and the seats are arranged so as to form comfortable couches, as shown in the longitudinal section. Referring to this view, it will be seen that of a pair of opposite seats one merely draws out to an extent limited by a hook at the back, while the other when similarly drawn out, tilts slightly as shown and draws down after it a portion of the back squab, which is fixed to a frame hinged to the frame of the seat. A link fixed to the partition limits the descent of the squab, while a link controls the drawing out and tilting of the seat, as shown. The arrangement appears a very satisfactory one. In the second-class compartment the trimming is of drab cloth, and the seats simply draw out, as shown by the dotted lines in the longitudinal section.

The lavatories are well fitted up, but the wash-hand basins and the toilette glasses over them are inconveniently placed in the corners, as shown in the plan. The lid of each watercloset is connected by a link with the flap which covers the mouth of the discharge pipe, so that when the lid is opened the flap is closed, and *vice versâ*.

The carriage is heated by briquettes placed in suitable iron casings, arranged under the seats, the arrangement being similar to that illustrated by Figs. 5, 6, 7, and 8, Plate CXLV., while the general internal fittings are good, and the carriage itself roomy and commodious. The weight of the vehicle empty is 11⅓ tons, so that, making an allowance for hand baggage, its weight, when full will be about 13½ to 14 tons. On account of this weight, and the great length of the carriage, it would, we think, have been preferable to carry it on three instead of two pairs of wheels, the middle pair being allowed some lateral play and their springs being arranged so that they were more lightly loaded than the others. Six-wheeled carriages, however, do not yet seem to have gained much favour on the continent, although here their use is fast gaining ground on most of our principal railways. In concluding our notice of the carriage just described, we should state that the workmanship was throughout most creditable to the builders.

We have now to describe the covered goods wagon constructed and exhibited by the same firm. The general construction of this wagon is shown by the views given in Plate CXLV., Figs. 2, 3, and 4, while the principal dimensions are as follows :—

	ft.	in.
Length inside - - - -	23	$4\frac{3}{8}$
Width „ - - - -	8	$4\frac{3}{8}$
Height „ at sides - - -	6	11
„ „ centre - - -	7	4
„ of doorways - - -	6	$6\frac{3}{4}$
Width „ - - -	4	11
Distance between centres of soles - -	6	$5\frac{1}{8}$
Diameter of wheels - - - -	3	$2\frac{5}{8}$
Wheel base - - - - -	13	$1\frac{1}{2}$

Weight empty, 6 tons 8 cwt.
Load, 10 tons.

As will be seen from the engravings, the frame of the wagon is entirely of iron ; the soles are $9\frac{3}{8}$ in. by $3\frac{1}{2}$ in. I-irons ; the headstocks $9\frac{3}{8}$ in. by $3\frac{3}{8}$ in. channel iron ; the longitudinal and transverse bearers, $5\frac{3}{4}$ in. by $2\frac{1}{2}$ in. channel iron ; and the diagonals, 2 in. angle iron. The manner in which the parts of the framing are connected by gusset-pieces will be seen from the plan, Fig. 3, Plate CXLV. The wheels are of the solid steel disc type made by Krupp, and the horn-plates have rubbing pieces riveted to them to fit the axle-boxes, a plan common in continental practice. The draw-bar is continuous with a volute draw-spring, and the buffers are outside with volute springs contained in wrought-iron skeleton cases.

The body is carried at the sides by wrought-iron brackets riveted to the outer sides of the soles, and the framing, which is of oak, is light but stiff. The side and corner pillars are about 6 in. by $1\frac{1}{2}$ in., and the diagonals are of the same scantling. The flooring is of 2 in. planking, laid transversely and lap-plated, while the side planking is of 1 in. boards tongued and grooved, and fixed outside the pillars. The end planking, which is also tongued and grooved, and placed inside the pillars, is $1\frac{2}{16}$ in. thick for about half the height of the wagon and 1 in. thick for the remainder. There is no transverse framing at the bottoms of the ends of the body, but the end pillars are each held at the bottom by a strap riveted to the upper flange of the headstock, and by a bolt passing through a corner knee, which is also riveted to the headstock. At their upper ends the end pillars are bolted to the outer sides of the arch rails instead of being framed into the latter, as is the usual practice here. The ends are stiffened transversely by diagonals placed inside the planking, and extending from the corner pillars at a little below the middle of their height to the floor, at about a third of the width of the wagon from the sides, as shown in the transverse section, Fig. 4, Plate CXLV. There is a sliding door on each side of the wagon, these doors being carried by rollers running on suitable rails, supported by the wrought-iron brackets already referred to. We have described this wagon in some detail because it is of a very useful type, which, with slight modifications, is very largely in use on continental lines. The wagon exhibited at Vienna was very well built.

The next vehicle we have to notice is one illustrated on Plates CXLVI. and CXLVII., namely, a composite carriage for the Lower Silesian Railway, constructed at the central works of the company at Frankfort. The principal dimensions of this carriage are as follows :—

	ft.	in.
Length of body outside - - - -	29	$6\frac{5}{8}$
Width „ „ - - - -	8	4
Height, inside, at sides - - - -	6	6
„ „ at centre - - - -	6	10
Wheel base - - - - -	16	$4\frac{7}{8}$
Diameter of wheels - - - -	3	$2\frac{5}{8}$

Number of passengers carried, five first and 23 second-class ; total, 28
Weight empty, 12 tons 4 cwt.

As will be seen from the above dimensions this is another instance of an unusually long and heavy carriage being mounted on four wheels only, a practice which we certainly cannot commend. Apart from this the vehicle under notice is very well designed, and its construction includes many points of detail of special interest. As shown by the engravings to which we have already referred, the body is divided into four compartments besides a central space, divided into two lavatories with watercloset. Commencing at one end there is first a second-class compartment seating eight passengers, next a first-class compartment with five seats, next the two lavatories, each occupying half the width of the carriage; next a ladies' second-class compartment with seven seats, and finally another second-class compartment like that first mentioned. The two lavatories communicate with the first-class compartment and ladies' second-class compartment respectively; in each of these compartments a seat being lost to make room for the necessary doorway. The three second-class compartments are each 5 ft. $10\frac{7}{8}$ in. long inside, while the length of the first-class compartment, inside, is 7 ft. $2\frac{5}{8}$ in. The lavatories are L-shaped in form, as shown, and are each 2 ft. $10\frac{1}{4}$ in. wide at the narrowest part. They are entered by folding doors, the two leaves of which are connected so that they open and close simultaneously.

The details of the lavatories include some ingenious arrangements designed with a view to economise space. Thus the partition between the two lavatories is made double, so as to accommodate a tank which can be filled from the roof, and which is fitted with cocks having discharge branches connected to them, the arrangement being such that when the branches are folded against the partition the cocks are closed, but when the branches are pulled out the cocks are opened. There is one of these branches in each lavatory. Beneath the tank are arranged two drawers one above the other, each drawer containing a wash-hand basin. One drawer pulls out into one lavatory, and the other into the other, and the arrangement is such that even when thus pulled out the overflow pipes of the basins and the pipes connected with the discharge plugs at the bottom communicate with suitable receiving trays from which wash pipes are led off through the bottom of the carriage (see Fig. 9, Plate CXLVII.). The basins when not in use are thus enclosed in the thickness of the partition, while when pulled out they occupy positions over the seats of the respective water-closets, and can be conveniently supplied with water by the branches from the cocks already mentioned. In each lavatory a mirror is conveniently placed over the wash-hand basin.

The carriage of which we are now speaking was characterised by two special features, which distinguished it from any other vehicle exhibited at Vienna. Thus, in the first place, it was lighted by gas made from peat-tar oil, this gas being capable of being compressed without its illuminating power being affected, and, in the second, it was fitted with a system of electrical intercommunication for the use of passengers. Of this latter apparatus it is not our province to speak here; but of the gas-lighting arrangements we must say a few words. The system on which the carriage was fitted up was that of Mr. Julius Pintsch, of Berlin, the gas being contained in a couple of cylindrical wrought-iron reservoirs placed beneath the framing of the carriage.* These reservoirs are charged at a pressure of 6 kilogrammes per square centimetre, or $85\frac{1}{3}$ lbs. per square inch, and the vessels contain a sufficient supply for a run from Berlin to Breslau and back, a journey of from $6\frac{3}{4}$ to $7\frac{1}{2}$ hours each way by the fast trains. The gas from the reservoirs passes suitable pressure regulators on its way to the burners, and at Vienna the latter burnt with great steadiness, and gave an excellent light. Details of this gas apparatus are given on Plate CXLVII., Figs. 1 to 8.

The carriage is warmed by "briquettes" contained in wrought-iron casings arranged beneath the seats, and capable of being charged from the outside. The arrangement is identical with that illustrated by Figs. 5 to 8, Plate CXLV. Special ventilators are provided in the roof, and the whole of the internal fittings are in very good taste. The first-class compartment

* The position of these gas-reservoirs is shown by dotted lines in the engravings to which we have already referred.

is trimmed with crimson plush velvet, and the second-class compartment with drab cloth. In all the compartments the seats draw out so as to form couches, while in the first-class compartment the squabs at the back turn slightly upwards as the seats are pulled out, so as to form comfortable pillows for the head.

The underframe is entirely of iron, the soles being $9\frac{1}{4}$ in. by 3·54 in. I-iron, placed at a distance of 6 ft. 5 in. apart from centre to centre; while the headstocks are $9\frac{1}{4}$ in. by 3·35 in., channel iron; the longitudinals 5·16 in. by 1·81 in., channel iron; the transverse bearers 6·97 in. by 3·27 in. I-iron; the diagonals running from near the centre to the corner of the frame, $1\frac{3}{16}$ in. angle iron; the diagonals connecting the headstocks and soles $2\frac{2}{16}$ in. angle iron; and the diagonals connecting the transverse bearers and soles 2·05 in. angle iron. The arrangement of these parts and their connections will be best understood by referring to the engravings of the carriage which we have already mentioned. The draw-bar is continuous with a volute draw spring, and the buffers are outside with volute springs contained in wrought-iron skeleton cases. The whole of the carriage is of very good workmanship, while the details of the design are well worked out. As we stated on a former page when speaking of a somewhat similar vehicle, it would, however, have been preferable to have added a third pair of wheels, making of course due provision for the requisite flexibility on curves.

The only vehicle now remaining to be described amongst the German exhibits of rolling stock in the annexe at the back of the Machinery Hall is the covered goods wagon constructed by the Stadt Eisenbahnbedarf und Maschienenbau-Actien-Gesellschaft Arthursberg, near Stettin, of which we give views on Plate CXLVIII. As will be seen from the views given, the constructive details of this wagon differ materially from those of the covered goods wagon exhibited by the Breslau Company, and already fully described by us. The underframe of the Arthursberg wagon is, like that of the one from Breslau, constructed entirely of iron, but in the former case there is also a series of timber cross-bearers placed above the underframing and supporting the floor and bottom sides of the body. In the Arthursberg wagon the body is in fact formed quite independently of the under-frame, while in the Breslau wagon this is not the case. In the Arthursberg wagon, too, the end pillars and intermediate side pillars are formed of light channel iron, and the planking is inside the pillars instead of outside, as is very commonly the case in Germany. The door and corner pillars are of timber.

The wagon has sliding side doors, and there are also on each side two openings fitted with louvres, these being useful when the vehicle is employed in the conveyance of horses, as all such wagons are liable to be in war time. On such occasions the wagon under notice is calculated to convey six horses or 40 men. The underframe is, as we have said, entirely of iron, but it includes no special features requiring notice here, and we will merely remark that the proportions of its parts are substantial. The draw-bar is continuous and carries an india-rubber draw-spring, the manner in which the end plates or stop-plates of the latter are given a bearing against double nuts on the bolts connecting the transverse bearers of the frame being new to us and very neat. The arrangement is clearly shown in the plan.

The wagon is fitted with a brake of a type very frequently met with on the continent, but not, so far as we are aware, in use in this country. Thus it will be seen on reference to the side elevation and part longitudinal section that there are two transverse brake shafts, one to each pair of wheels, these shafts being carried by the brake-block hangers. By means of a bell-crank connecting rods, and a short equalising lever, the pull exerted by the brake screw is transmitted to these two shafts in equal proportions. Each brake-shaft carries at its ends a pair of short levers connected by links to the brake block hanger on the other side of the wheel, and the brake blocks are thus made to press directly against each other, while each block being hinged to its hanger by its centre can adjust itself to the wheel. To ensure the brake-blocks being both removed from each wheel when the brake is slacked off, the two hangers of each pair are connected near their upper ends by links coupling them to opposite ends of an intermediate lever oscillating on a fixed

fulcrum, as shown in the view to which we have already referred. At one end of the wagon an elevated covered seat is provided for the guard, as shown The principal dimensions and the weight of the wagon are given on the engraving, and we need merely add here, therefore, that the vehicle was well built, and of a useful type for many purposes.

The hospital train exhibited by the Wagenfabrik Ludwigshafen was the most complete of its class in the German section of the Sanitary Pavilion. It consisted of four carriages, namely one kitchen car, one surgeon carriage, and two ambulance wagons. A special interest attached itself to this exhibit, from the fact that it was arranged exactly like one of the hospital trains employed by the Germans during the late war. Before the outbreak of that war considerable attention had been paid in Germany to the subject of railway ambulances, and but few alterations were made in the arrangement of the trains when they were subjected to the test of experience. The first to cross the French frontier was the Bavarian train, but this not being provided with a cooking car, and having no means of communication from one carriage to the other, proved of little service. Then followed the Würtemberg train, which required but few subsequent alterations. The Prussian trains, which were arranged by Professor Virchow, were also satisfactory in their working, as were others sent by private societies, such as the Mayence, Cologne, Hamburg, and Palatinate trains.

The Ludwigshafen train already mentioned, is illustrated by Figs. 1 to 8, Plate CLI.; Figs. 1, 2, showing the ambulance car, Figs. 3, 4, the kitchen car, Figs. 5, 6, the attendants' car, and Figs. 7, 8, the doctor's carriage.

The conditions laid down to be fulfilled in the design of this train were as follows:—1. That a free passage from end to end of the train be provided. 2. That perfect ventilation be secured. 3. That the carriages should be well lighted. 4. That suitable couches should be provided for the patients, these couches being properly suspended so as to avoid the shock occurring when the train is in motion. 5. That the carriages should be properly heated; and 6. That means be provided of storing and cooking a sufficient supply of food for the patients in the train.

Obviously it was impossible to adapt existing passenger carriages to fulfil all of the conditions above described, but on the other hand, goods' wagons were found to be, after slight modification, well suited for the purpose. It was necessary to make doors at the ends, and to add the end platforms, by which the circulation from one car to another was effected. The side doors however, were retained, as they were found invaluable for passing in patients brought to the train upon stretchers and unable to move. The rigid springs of the goods wagons were made sufficiently elastic for their new purpose by taking out three plates from each, so that with a very slight delay and expense the vehicles themselves were got ready for work. In cases where the existing lights were not sufficient glazed windows were added. Some difficulty was found to exist in obtaining efficient ventilation; indeed, in the Ludwigshafen, as well as in the other sanitary trains, the difficulty was never thoroughly surmounted. So long as the carriages were in motion of course the ventilation was good, but there ceased to be a good change of air when they were at rest. During the cold weather, however, this evil was remedied by the use of suitable stoves in the vehicles, which were so arranged as to warm the air before it was admitted into the carriage. The following was the composition of the entire Ludwigshafen train, represented by four cars at Vienna. One luggage van, ten ambulance cars, each containing eight beds, one guard's van with brake, one surgeon's carriage, and two kitchen cars, one store carriage, one carriage for attendant, ten ambulance cars, each with eight beds, and one luggage or disinfecting car. As the cubic contents of each ambulance car amounted to nearly 1,000 feet, each patient had 125 cubic feet of space. In the Prussian cars this was a little exceeded, and in the Bavarian, which contained only five beds, it was nearly doubled. The stretchers were suspended in the Prussian cars by rubber bands or by spiral springs. In the Ludwigshafen vehicles hemp straps were used, the vertical oscillations being checked by the elasticity of the frame of the stretcher, while lateral shocks were checked by padding. Curtains protected the end door of each carriage. The

larger of the two kitchen cars was designed to prepare food for about 200 men, the full complement of the train. A large stove was necessary for this. In the Ludwigshafen car the stove is about 6 ft. long by 3 ft. 6 in. wide. It has two boilers, each holding nearly 40 gallons. Besides the stoves are folding tables and water barrels holding 70 gallons, sideboards, frames for plates, knives, &c.

The smaller kitchen car is used principally for making coffee, broth, &c., and contains sleeping accommodation for the cook. The store carriage contains presses for blankets, bedding, &c. as well as bunkers for coal, wood, and potatoes. The surgeon's carriage, a very primitive affair as compared with that of the French train, is provided with the simplest accommodation for the doctors, and cupboards for medicine, instruments, bandages, &c.

One lazaret car was sent by Mr. H. N. Plambeck, of Hamburg. It has no end entrances, and is therefore unsuited to form part of a hospital train. It is, however, thoroughly adapted for conveying wounded soldiers to depôts, or to points where they may be shifted to a more complete train. The car contains ten beds, which are suspended by cords attached to the roof of the car by means of gripping hooks, the points of which bear against the roof sticks, and are set up tight by an adjusting screw. The lower part of the hook is fastened to a small frame containing a vertical bar looped at the lower end, and enclosed within a coiled spring; the cord supporting the stretcher is attached to this loop, so that the weight of the bed and patient is carried by the coiled spring.

A different arrangement for supporting the stretcher is adopted in the hospital carriage for the Lower Silesian Railway, in which vertical posts are placed in position corresponding to the head and foot of the stretcher, the ends of which are passed through loops attached to the posts, small volute springs being interposed to reduce the motion. This car contains ten beds. This detail, as well as the general arrangement of the carriage, is shown in Plate CL. The kitchen car of the same company, and represented by a model at the Exhibition, is shown in Plate CXLIX. and Fig. 10, Plate CXLVIII., from which the general arrangement will be at once understood. It will be seen to consist of one large compartment, having end doors opening to end galleries, a passage through the train being afforded by end flaps which can be lowered to bridge over the space between the carriages. In the centre of the carriages, on one side, is a well arranged cooking stove, and opposite, a table provided with scales, weights, and other suitable appliances. In convenient cupboards are stored the cooking utensils, and an ample collection of plates, dishes, glasses, &c., while there is storage for wood and coal, a good-sized water tank, and conveniences for washing up plates, &c. Each end gallery also carries an ice safe. The chimney of the stove, it will be noticed, is formed of double pipes, the annular space between which not only protects the woodwork from the heat of the internal flue, but also serves as a ventilating shaft, the air being admitted to it by openings, as shown in the longitudinal section on Plate CXLIX. Altogether this carriage has been excellently arranged for its intended purpose, and the space available is well disposed of.

Finally, we may mention here the four Bavarian hospital carriages exhibited by Messrs. Klett and Co., of Nuremburg. They also are ordinary goods wagons adapted for the purpose. The ambulance car contains, as already stated, five beds, which are supported by light plate springs resting on the floor of the car. A watercloset is placed at the end of the vehicle, and in the centre, at one side, is a washstand and two seats. On this side there are therefore only two beds, three being on the other. Above each bed are shelves and basket for holding sponges, &c., &c. The second car contains stores, the space being well occupied, and lines are provided for hanging up linen to dry. A kitchen car and doctor's carriage completed this exhibit, the latter containing one bed and washstand, with presses for medicine, bandages, linen, and other stores.

In concluding our notice of the German exhibits of rolling stock we may mention that Mr. Rudolph Leder, of Quedlinburg, Harz, exhibited at Vienna some of his tip wagons and several cast-iron disc and wrought-iron spoked wheels. These wheels are cast in chills of a mixture of tough grey charcoal iron and white fine-grained charcoal steely iron. The tip wagons are repre-

sented by Figs. 9 to 14, Plate CXLI., of which Figs. 9 and 10 show a side tip coal truck of 5 hectolitres contents (17·65 cubic feet). The sides of the body are made of wrought-iron plates $\frac{3}{8}$ in. thick, the bottom of plates $\frac{2}{10}$ in. thick, and the whole body is carried upon a wooden under-frame, and turns through an angle of about 35 deg. round the joint *a*, fastened both to the body and the frame. The side flap that opens when the truck is tipped is fastened by means of the round bar *b*, with the catches *c*, *c*, and the levers *d*, *d*. The axles are fixed to the wooden frame and the wheels run loose on them.

A universal tipping truck of between 5 or 6 hectolitres (17·65—21·18 cubic feet) capacity is represented by Figs. 11 and 12, Plate CXLI. The body is made of wrought-iron plates $\frac{1}{8}$ in. thick for the sides, and $\frac{3}{10}$ in. thick for the bottom; the under-frame is made of cast iron and consists of the two plates, *a*, *a*, the lower one of which is provided with four brackets for the axle-bearings, the axles being fastened by means of wrought-iron straps and cotters. The two plates of the frame touch each other at the middle only where they have the one a turned boss, and the other a correspondingly turned socket, whilst the side surfaces, $1\frac{2}{10}$ in. in width, take a bearing only in case the trucks are loaded on one side more than on the other. The two brackets *b*, *b*, are riveted to the body in such a manner that they form with the brackets *c*, *c*, of the upper plate *a*, one joint, round which the truck is tipped. The small spring catch *d*, prevents the tipping of the truck until desired. If the latter has to be turned, the lever *e*, the fulcrum of which serves also as a connexion between the two plates, is lifted, and the small projecting piece *g* of the lever is taken off the notch in the lower plate in which it had been fixed. Such a notch is provided at each side of the plate, so that the body can be turned and tipped in either of four directions. For the better handling of the truck the body is provided with the handrail *h*. Fig. 13, Plate CXLI., represents a sack truck with wooden platform and wooden underframe, no example of which was exhibited at Vienna; the cast-iron wheels are fixed in the same manner as for the other trucks. The general arrangement of this truck is easily understood from the engraving. The wheels of all the trucks run loose on their axles, and are provided with caps *b*, screwed on and tightened by a leather disc, as shown in Fig. 14, Plate CXLI.; these caps serve for the reception and gradual supply of the grease, and prevent at the same time the running off of the latter.

Belgium.

In the Belgian section the only passenger vehicle exhibited was a very fine saloon carriage with sleeping accommodation, shown by the Compagnie Belge pour la Construction de Machines et de Matériels de Chemins de Fer, of Brussels, a company of which M. Charles Evrard is the managing director. The general arrangement of this carriage is shown by the outline views, Figs. 9 to 12 on Plate CLI. From these it will be seen that it is a six-wheeled vehicle, of which the body is divided into three main compartments, besides two smaller sub-divisions (containing each a watercloset and lavatory), and a transverse passage C, into which the entrance doors open, and from which access is obtained to the various compartments already referred to.

The under-frame is entirely of iron, the soles, headstocks, and transverse bearers being of channel iron, $9\frac{3}{8}$ in. deep, and the whole frame being strong and well put together. The draw-bar is continuous and acts on a draw-spring consisting of two volutes. At each end the carriage is fitted with Zürth's safety apparatus, this consisting of a pair of links hinged to the headstock, one on each side of the draw-hook, these links carrying between their outer ends a supplementary draw-hook which can be coupled to the next carriage. In addition, the usual safety chains are also provided, the bolts of these pulling against india-rubber pads. The buffers have wrought-iron cases and plungers, and are fitted with spiral springs made by Brown, Bayley, Dixon & Co., of Sheffield.

The six wheels on which the vehicle is carried are of wrought iron, forged by hydraulic pressure, according to the process of MM. Brunon Frères, of which the Compagnie Belge are licencees. The tyres and axles are of Bessemer steel. The axle-boxes are adapted for oil lubrication, and are constructed on

the Gobert system, in use on the Belgian State Railways. Axle-box guides of cast-steel are riveted to the horn-plates, but the axle-boxes of the central pair of wheels are allowed considerable lateral play, so as to permit the carriage to traverse curves easily. The bearing springs are 6 ft. $6\frac{3}{4}$ in. long between centres, the centre springs consisting of nine and the end springs of ten plates. The total wheel base is 21 ft.

The body of the carriage is 33 ft. $10\frac{3}{4}$ in. long, by 8 ft. $2\frac{1}{2}$ in. wide inside dimensions, while the height at the centre is 8 ft. $6\frac{3}{8}$ in., the roof forming an elliptical arch, as shown in the cross sections. Both the roof and floor are double. India-rubber cushion springs carried by brackets fixed to the underframe, are interposed between the latter and the body, and the floor of the carriage is covered with oil-cloth laid upon a layer of felt.

The arrangement of the body will be readily understood on reference to the plan, Fig. 11, Plate CLI. A single door on each side gives access to the transverse passage or ante-chamber C, and from this the doors open right and left to the compartments D and S. In the passage C are cupboards for containing articles required for the surface of the carriage. The saloon S, which forms the chief compartment contains two large couches, which also form beds, and of which the backs can be turned down into a horizontal position, so as to afford additional accommodation. When thus turned down the backs are supported by being hung from the side walls. The mattresses, &c. are in the day-time stowed away in drawers beneath the couches. There are also fixed against one of the transverse partitions two other seats, one accommodating two and the other one person. If necessary the movable chairs from the compartments D and H can be brought into the saloon to increase the sitting accommodation. The couches and seats in the saloon are trimmed with Gobelin rep, while the sides and ceiling are also covered with rep, that on the ceiling being painted to imitate Gobelin tapestry. Two tables are placed, as shown in our sketches, with mirrors above them, and the whole of the interior decorations are well finished and in good taste.

Of the compartments D and H, the former is reserved for ladies and the latter for gentlemen. The furniture of these two compartments is identical, and it consists in each of two movable and four fixed seats, the cushions of each pair of the latter drawing out so as to form a bed, as shown on one side of the plan and in the longitudinal section; the spaces left by the cushions when drawn forward are filled by parts of the back squabs which turn down for that purpose. Above each pair of side seats there can be arranged an upper bed, the positions occupied by the these upper beds when turned down or stowed away respectively, being shown by one of the transverse sections. The upper beds, when folded up, also serve to enclose the bed furniture for the lower couches. In the compartment D the seats are covered with velvet and the walls with silk rep of a clear grey colour, while the fittings generally are of white maple with mouldings of rosewood and amaranthe. In compartment H the seats are covered with green Utrecht velvet and the walls with silk rep, while the woodwork is ornamented by mouldings, &c. of ebony and walnut. The two ends of the carriage are each occupied by a lavatory and watercloset, communicating with the compartments D and H respectively. Beneath the wash-hand stands of the lavatories are presses for the bed and other linen.

The warming of the vehicle is effected on the Chaumont system by means eight spirit lamps placed beneath the body, and outside the soles; the products of combustion from these lamps traversing pipes arranged in the thickness of the flooring, as shown in our sketches, and the air entering through the double sides of the lamps becoming heated by contact with these pipes, and escaping into the carriage through small holes pierced in the copper plates by which the pipes are covered. From the positions of these plates in front of the various seats they form foot warmers. The ventilation is effected by seven ventilators (two in the saloon and one in each of the other compartments), these ventilators being fixed in the roof, and each communicating with a Neuhallier exhausting cowl. The carriage is lit by five ordinary oil lamps, placed as shown, while candle lamps are also fixed in the saloon on each side of each window, and another is placed in the passage C.

The panels of the carriage are of iron, with iron mouldings and joint covers, and the exterior is exceedingly well painted; in fact the finish of the vehicle throughout is of the highest class. The weight of the carriage empty is about 13 tons, and its price was stated at the Exhibition as 42,000 francs or about 1,680*l.*

The other rolling stock exhibits in the Belgium section consisted of three iron coal wagons, of which two were exhibited by the Société Générale d'Exploitation de Chemins de Fer, Tubize, and the other by Messrs. A. Durieux and Co., of Louvain.

The two wagons shown by the Société Général d'Exploitation de Chemins de Fer—who have works at Tubize, Nivelles, and Sambre—are illustrated in Plates CLII. and CLIII., and they had been constructed at the Tubize works. The first of these wagons shown by Plate CLII. is of the ordinary type made by the company, and its construction will be clearly understood from the engravings without special description. The body is 18 ft. 0½ in. long by 8 ft. 3¼ in. wide and 2 ft. 9½ in. high, its capacity being 412½ cubic feet. The weight of the wagon empty is 5·22 tons, and with the exception of the floor planking it is constructed entirely of iron. It is, as will be seen, fitted with side doors, and is of a very useful class.

The other wagon, shown by Plate CLIII., is of a new type and is of very light construction. In this case the wagon has no frame in the ordinary sense of the term, the body being stiffened by a 4½ in. by 2⅝ in. channel iron along the bottom corners, and by top side beams of deep T-section, namely, 8 1/16 in. by 2 3/16 in., these beams being continuous from end to end, and not being cut at the doorways. The end uprights, and the transverse bearers, are of the section shown in the details, the depth being 4 in., and the widths of the two flanges 1½ in. and 3⅜ in. respectively. The door pillars and diagonals at bottom, are of channel iron of the section shown, namely, 3 1/16 in. by 1¾ in., while the intermediate side uprights are also of channel iron 2⅜ in. by 1 1/16 in., as shown by the detail sections.

One of the chief peculiarities in the wagon is the construction of the horn-plates. These are placed outside the springs, the vertical legs being curved outwards, and riveted to the bottom bars, as shown in the transverse section, while the diagonal legs incline inwards, and are made to serve as spring hangers, as shown in the side elevation and plan. This arrangement undoubtedly saves weight, but it scarcely looks so rigid and strong as could be wished. The wheels are of wrought-iron and of the pattern shown by the engraving. The wagon is 16 ft. 4½ in. long by 8 ft. 3¼ in. wide, and 3 ft. 5⅜ in. high, and its capacity is 501 cubic feet. The diameter of wheels is 3 ft. 2½ in., and the weight of the wagon empty is 5·16 tons only, undoubtedly a very light weight for such a capacity.

The third wagon—shown by Messrs. A. Durieux & Co.—was like those from Tubize, built entirely of iron. The soles were of 6¾ in. by 2½ in. channel iron, the headstocks of 10 in. by 3½ in. channel iron, and the diagonals of 5⅞ in. by 3 in. ⊢-iron. The frame appeared somewhat wanting in transverse connexions, there being only two transverse bearers of angle iron, and those being used to carry the brake-hangers. The body was stiffened by four 3 in. by 3 in. T-irons, which extended across under the floor and above the under-frame, and were turned up at the ends to form the side pillars. The end pillars were also of 3 in. by 3 in. T-iron, and there were two at each end. The body had side doors, and there was provided at one end a raised seat for the brakesman. The brake was applied to both sides of all the wheels, and was somewhat similar in arrangement to that which we have described as being used in the covered goods wagon from Arthursburg. The brake-blocks were of wood with springs interposed between them and the hangers. The draw-bar was continuous with volute draw-springs and screw couplings, while the buffers had wrought-iron skeleton cases enclosing volute springs, and small volutes were also applied to the safety chain-bolts. The wagon was exhibited unpainted, and the workmanship was good. The weight of the wagon empty was 5 tons 18 cwt.

HOLLAND.

The Dutch did not exhibit any example of railway rolling stock, but Mr. J. W. Stous Sloot, Tolsteegsingel, Hoch Bleekstraat, Utrecht, exhibited an axle-box, which has been already in use for sometime, with very satisfactory results, on the Dutch State railways, and which we illustrate on Plate CLVI., Figs. 1 to 12. The box is only filled before leaving the shops, and has capacity for one litre of oil. When necessary, however, oil can be added through the opening A (see Fig. 2, Plate CLVI.), after the box is closed. The bearing, of gun metal, is cylindrical on the convex side, and is only fitted in the middle with a rectangular projection B, thereby facilitating the adjusting of bearing in the box, as it is only necessary to turn it to the right diameter and nothing more. When the projection B, of the bearing is made 2 millimetres lower and two millimetres narrower than the corresponding cavity in the box, and the bearing is turned to a diameter 2 millimetres smaller than that cavity, the bearing will be found to be movable in the direction of the centre line of the axle, and also to have some lateral play. In the upper part of the box are cast the rectangular cavities C, C, wherein are fitted the carrying plates D, D, fastened by the pins E, E.

The lower part of the box is so constructed that a loosening of these pins, E, E, and consequent falling of the carrying plates D, D, is only possible when the two parts of the box are disconnected. The lubricating apparatus consists of two carrying plates D, D (Figs. 1, 2, and 6), the plate L, with the guide M (Figs. 5 and 12), the pad or brush sewn on the sheet metal plate and case O, and the two springs P, P (Figs. 1, 2, 5, and 7, Plate CLVI.).

The slots, g', g', g'', in the carrying plates D, D (see Fig. 6)—of which the parts F, fit in the cavities C, of the upper part of the box—carry the sheet-metal plate L. The slots are so arranged that, when the plate L is fixed in the highest of them, g', g', the pad or brush still properly bears against the journal, when the latter is but 65 millimetres in diameter, and the bearing is worn out to its minimum depth; while, when the plate L is inserted in the lowest cuts g, g'', the pad or brush still properly bears against the journal when the latter has a diameter of 95 millimetres and the bearing has its maximum depth or thickness. The plate L and case M (see Fig. 5, Plate CLVI.) are made of sheet iron. The pad or brush (see Fig. 7), is sewn with fine copper thread to the sheet-iron plate G, on which is fixed the guide. The two cast-steel springs P, P, which press the pad or brush against the journal, are riveted and soldered to the plate G by two hoops of brass. The oil carried by the pad or brush to the journal falls after lubricating the latter into the lower part of the box on the inclined plate J (see Figs. 1 and 2), and thence through the filter K, and the hole R, in the oil reservoir A^2. The centre hole H, in the partition J, is fitted with the sheet-metal case B (perforated with small holes) nearly reaching to the bottom of the lower part of the box C^2, in order to prevent the spilling of oil outside the reservoir. When putting the different parts of the b toget her for wor ing,the following system is adopted: First put the bearing (after being adjusted in the box and on the journal) in the upper part of the box and both together on the journal. Put the pad or brush sewn on the sheet-metal plate and case O, on the plate L, and this plate in the slots g', g'', of the carrying plates D, D (the proper slots being selected according to the diameter of the journal and thickness of the bearing), the parts F, F, of the carrying plates D, D, in the rectangular cavities C, C, of the upper part of the box, and fasten these plates with the pins E, E. When this is done the leading man has to see if the pad or brush presses suitably against the journal, and if the springs have got enough play; if not he has, according as the case may be, to put the plate L into lower or higher slots, g', g'', of the carrying plates D, D. When the man in charge has satisfied himself that everything works well, the pad or brush is saturated with oil, and the lower part of the box (the cavity A^2 of which has been previously filled with one litre of oil) is fitted and secured to the upper one by means of the bolts and nuts x, which are first fastened to the lower part of the box and serve as guides when coupling the two parts together.

The box is further closed at the back part by a ring (Y, Fig. 10, Plate CLVI.),

formed of two sheets of felt sewn together and tightly fitting the grooves in the upper and lower part of the box, in order to prevent the entrance of dust and sand. The pad or brush consists of a worsted fringe on a linen weft. The wicks of the pad are so long that they reach to the bottom of the box when the pad is in its highest position. Altogether, Mr. Sloot's axle-box is of very simple construction, and the details are well worked out to meet the requirements of practical working.

Switzerland.

Switzerland was represented in the division of which we are now treating, by two carriages shown in the Machinery Hall. Of these carriages, which were constructed by the Schweizerische Industrie Gesellschaft, of Schaffhausen, the one was a composite and the other a third class. The composite carriage, which was intended for the Royal Hungarian State Railway, was divided into three compartments, the central one being first, and the two end compartments second class. The internal fittings were comfortable, but characterised by no special features. The first-class compartment seated six, and each of the second-class compartments eight passengers, thus making 22 passengers in all. The vehicle was carried on four wheels, and had a composite under-frame, the soles being of channel iron, and the rest of the frame of timber. The buffers and draw-springs were volutes, and the draw-bar was continuous, while india-rubber pads were fitted to the safety chain-bolts.

The third-class carriage by the same makers was one which had been for some time running on the Western Railway of Switzerland, and it was exhibited chiefly to show Weibel's system of heating apparatus, an apparatus which we shall describe directly. The carriage had five compartments and seated 50 passengers. It was carried on four wheels and had a wooden frame, while the arrangement of the buffing and draw-springs was similar to that of the carriage illustrated (see Plate CLIV.) in connexion with the account of the heating apparatus to which we have just referred. The accommodation afforded by this carriage was somewhat cramped, and beyond the heating apparatus there was nothing about it requiring special notice.

We have referred above to a system of heating railway trains patented by Messrs. Weibel, Briquet and Co., and we shall now describe it by the aid of the views given on Plate CLIV., these views, however, representing it as applied to a composite carriage and not to a third class, as was really the case at Vienna. According to Messrs. Weibel, Briquet, and Co.'s system, each carriage is warmed independently, each carriage having its own stove, and the heat being communicated from this stove to the various compartments by hot water circulating in suitably arranged pipes. Thus referring to Plate CLIV. it will be seen that the stove is placed under the floor of the carriage, beneath the seat which has its back to the end. A hot water pipe *h* leads out of the top of the stove along the seat under which the stove is fixed to the corner of the carriage, and ascends to the level of the roof, where the expansion chamber *r* is placed. Inside the carriage the pipe *i*, *i*, runs off from the pipe *h*, just under the roof on one side of the carriage to the other extremity; this distributing pipe feeds the descending branches *k*, *k*, *k*, with hot water, and each of these pipes follows the angles of a compartment and descends to the level of the floor, where it is divided into two branches, forming the warming pipes, properly so called. These pipes are marked *l*, *l*, *l*, and they cross the carriage on the floor beneath the outer edge of each seat. At the other side they pass through the floor, and by the descents *m*, *m*, *m*, are joined again to the collecting pipe *n*, *n*, which takes back the cooled water to the boiler by the pipe *o*.

The cause of the circulation of hot water is of course its expansion by heat, and the consequent decrease of its specific gravity. The warm water rises, whilst the cooler water flows towards the boiler; the colder a part of the pipes becomes, the more dense is the water contained in it, and the more rapidly is the hot water drawn towards that point by the flow of cold water; the result of this property is a remarkable equality in the temperature of every part of the same compartment with the same circulation.

To regulate the pressure of the water, and to prevent it from increasing, it is necessary that the highest point of the set of circulating pipes should be in free communication with the atmosphere. This is the object of the expansion chamber *r*, *r*. This chamber, open at the top, allows the exit of the air given off by the water when heated. The pipes are so fixed as to have an inclination towards the expansion chamber, so as to favour the disengagement of air. Generally, in fitting up hot-water pipes, care is taken not to lay them horizontally; and contrary slopes at acute angles are carefully avoided because the air would lodge in the apex and hinder the circulation of water. In railway carriages it is impossible to place the pipes in a sloping position; the distributing pipe *i*, *i*, *i*, and the heating pipes *l*, *l*, *l*, must be laid quite horizontal, and we must depend on the different levels which the carriage takes in ascending and descending inclines, and on the shaking of the train, to displace the air. This arrangement has been perfectly successful, the circulation being kept up in travelling with great regularity.

The expansion chamber ought always to contain a certain quantity of water to supply the void produced by the disengagement of the air bubbles contained in the pipes; besides, while the carriage is being warmed, this chamber receives the increased volume of water occasioned by expansion. It is necessary to use some means to prevent the shocks which the carriages receive occasionally from spilling the water contained in the chamber. For this purpose the chamber is furnished with a small conical tube, the extremity of which is covered by a little cupola supported by three feet fixed to the lid of the expansion chamber. This cupola, of copper, is pierced with small holes. When the sudden meeting of the buffers throws the water in the chamber against the lid, the cupola becomes filled with water, and prevents the latter from being spilled by the recoil. When the water is no longer disturbed, that which filled the cupola runs back through the holes and the communication with the atmosphere is re-established.

We have stated that the stove is fixed to the floor of the carriage. It was at first placed outside the carriage, against the end, supported by brackets above one of the buffers. But this position being found dangerous to the men employed in arranging the carriages, it was abandoned. After some experiments for the purpose of determining the minimum size of stove which would work effectively, it was found possible to have it small enough to go conveniently beneath the floor of the carriage. The place available for the purpose is very limited. The outside diameter of the stove is determined by the distance between the draw-bar and the bolt of the safety chain Its depth is regulated by the space between the axles and floor, due allowance being made for the play of the springs.

To fulfil these conditions the outside diameter of the stove is 14 in., its height 20 in. Its upper surface is closed by a plate of cast iron bolted to angle iron, which forms the upper side of the stove; this cast metal plate has fixed to its centre the hopper for supplying the fuel, and at its side is the tube from which the smoke-pipe proceeds. The interior of the fuel hopper is lengthened into a sort of funnel. The fire-place is of conical shape, 10 in. broad at the bottom, and at its upper end it is so formed as to leave round the funnel of the hopper the space of about three-eighths of an inch; through this opening the products of combustion escape, and collect around the prolongation of the hopper, thence entering the smoke-pipe. The object of contracting the fire-place at its upper part, where it is only 7½ in. in diameter, is to impede the combustion of coke at this point, and at the same time to diminish the possible radiation of the fire against the iron plate. The result is satisfactory, the temperature of the hopper plate remaining low, and the products of combustion heating the smoke-pipe very slightly.

The grate is supported in a ring of angle iron fixed to the bottom of the stove; it is hinged and kept in its horizontal position by a bolt.

The diameter of the grate is 8·8 in.; its surface area 60 square inches. The consumption of coke per hour is less than 2 lbs., so that the consumption is only at the rate of 4·8 lbs. per square foot of grate surface per hour. This extremely moderate consumption of fuel arises from the fact that coke burns slowly in contact with surfaces kept by water at a low temperature. All

round the fire there is a circle in which combustion is very slow, active combustion being confined to the middle of the fire. Notwithstanding these circumstances, a heating surface of $1\frac{1}{2}$ square feet in contact with the fire suffices to heat a surface of $65\frac{1}{2}$ square feet as follows:

	sq. ft.
Surface of pipes inside the carriage	48·4
Surface of pipes outside (to collect and return water)	11·4
Outer surface of the stove	5·7
Total surface in square feet	65·5

The supply of fuel is kept up by the hopper, the opening of which is placed against the end of the carriage. The fireplace takes 12 lb. of coke; the hopper holds 8 lb. or 10 lb. more. If the fire is allowed to go down very low, a complete supply to the stove and hopper will maintain the fire $10\frac{1}{2}$ hours at the rate of 2 lb. per hour; but the quantity contained in the hopper only should be considered as being in reserve, and this is enough for $4\frac{1}{2}$ hours. When the carriage is stationary the combustion is slower, and scarcely amounts to $1\frac{1}{2}$ lb. of coke per hour; a complete supply to stove and hopper then lasts 13 hours It would be easy to increase the store of coke by increasing the height of the hopper, and the latter could without inconvenience be raised to the level of the roof, so that it might be filled from the top of the carriages in the same way that the lamps are lighted.

The hot-water pipes are of drawn iron $1\frac{1}{4}$ in. internal diameter. They are joined with screw collars, like gas pipes; this is a simple method of union and answers very well, no escape being produced by the jolting of the train. There are in the whole apparatus but two flush joints on the pipe *o*, *o*. The object of these joints is to admit of easy disconnexion when the body of the carriage requires to be removed for repairs. The entire apparatus is fixed to the carriage body, and rises with it; the stove passes between the draw-bar and the bolt of the side chain; and only the pipe *o*, *o*, which passes under the frame of the carriage, presents any obstacle; it is therefore necessary to make its removal easy.

The total length of the hot-water pipes is $145\frac{1}{3}$ feet, of which $118\frac{1}{2}$ feet placed in the interior of the carriage make the surface really utilised $48\frac{4}{10}$ square feet. The cooling area of the carriage, or the area of the exposed external surface, is equal to 666 square feet. The proportions of the different surfaces are: heating surface of the stove to the surface of emission $\frac{1}{13}$; surface of emission utilised in the interior of the carriage to the cooling surface of the carriage $\frac{1}{15}$.

To complete the description of the apparatus we must mention the funnel *q*, communicating, by the pipe *p*, with the lowest point of the circulation *o*. By filling the apparatus at the lowest point it is certain to be filled completely; the water ascends, driving before it the air, which goes out by the expansion chamber. This arrangement has been adopted to render the refilling of the apparatus easy if it should be found convenient to empty it, when the train is not in use, to prevent the effects of frost. Up to now the fires have been kept up at night. When the carriage is not in motion the consumption of fuel is, as we have stated, very small, and falls to $1\frac{1}{2}$ lb. per hour; the hopper has not to be refilled; the watchman need only shake down the cinders once in the night; by this simple means there is no danger of accident. If the carriage stands out of use a considerable time, the pipes should be emptied by means of the cock *s*. The quantity of water contained in the whole apparatus is under 14 gallons. All danger from frost may be avoided by mixing 40 per cent. of glycerine with the water.

The apparatus is managed thus: Before the train starts, the cinders are raked and the coke falls; then the hopper is filled with small pieces of coke as big as a walnut. The motion of the train causes the fire, which was dull while the train was standing, to burn up; the cinders fall on the road of themselves. At the principal stations a man passes a little hooked rod between the bars of the grate to rake out the cinders which the shaking of the train has not thrown out, and fills up the hopper. These operations are performed

very quickly, and when done the fires require no further attention till the arrival of the train at the next principal station. On the Western Swiss lines the longest run without touching the fires, is made between Bienne and Lausanne (about 66 miles), which is done in four hours and two minutes by slow trains. From the 31st December 1872, to the 17th January 1873, inclusive, the consumption of fuel for two carriages, one of the second class with 40 seats, and one of the third class with 50 seats (this latter being the carriage shown at Vienna), was 12 cwt. 0 qr. 6 lb. or 6 cwt. 0 qr. 3 lb. per carriage. The mean consumption for 24 hours is therefore 40 lb. It may be considered that while travelling the consumption is very nearly 2 lb. per hour per carriage. During the 18 days above referred to the mean difference between the temperature, inside and outside the carriage, was 27° Fahr.

The fierceness of the fire, and consequently the heating power, can be decreased to some extent, by means of a damper placed in the smoke-pipe; the damper, however, must never be quite closed or the fire would go out. The loss of water by evaporation through the expansion chamber is about a quart a day. As the water need not always be kept at the same level in the expansion chamber, water need be added only every two or three days.

The trials of this apparatus made on the lines of the Western Swiss Railway have been very satisfactory, and following up the experiments already made, the Western Swiss Railway Company decided to apply this system to 25 new carriages of the first, second, and third class. Altogether the apparatus is one of a very practical kind, and of which the details have been well worked out, and it appears well worthy of attention.

Italy.

Italy showed one carriage in the Machinery Hall, this being, as far as we could judge from the exterior, a kind of saloon carriage for special service, but of this we cannot speak with certainty, as the interior was never accessible during our visits to the Exhibition. The carriage was built by the Società Nazionale d' Industrie Meccaniche, of Naples, and was carried on four wheels. The frame was of the composite type, and the wheels were fitted with a slide brake, the brake shaft being hung by short links from the centre of the bars or slides connecting the axle-boxes. The object of this arrangement was apparently to secure an equal thrust on each of the thrust rods connecting the levers on the brake shaft with the brake blocks, but owing to the disturbing influence of the strain by which the brake-shaft is caused to turn, this end was not attained. The brake-blocks, we may add, were not carried by brackets or holders sliding on the slide bars as is usually the case in sliding brakes, but themselves slid in guides fixed to these bars. The brake was worked from a covered seat provided for the guard on the roof at one end. The general finish of the carriage was far from good, the workmanship of the running gear being very rough.

In addition to the vehicle just spoken of, Italy showed in the Mont Cenis tunnel annexe examples of the very comfortable carriages used for the Mont Cenis traffic, together with examples of the gas-lighting apparatus and drawings of the arrangements used for the manufacture of the gas and for supplying it to the carriages. The whole exhibition was a most interesting one, and merits a full description.

The lighting by gas of the direct trains between Turin and Modane was commenced shortly after the opening of the line across the Alps through the Mont Cenis tunnel, its adoption having been decided upon with a view of adding to the comfort of the travellers during their transit through the numerous and lengthy tunnels which exist on the line between Bussoleno and Modane, and also to increase the feeling of security of the passengers, many of whom, particularly ladies, cannot, when traversing the great tunnel, free themselves from a certain feeling of uneasiness, which, however, the conditions of the traffic by no means justifies.

The system adopted is really a slight modification of that of M. Cambrelin, the chief of the lighting department of the Belgian State Railways, this system being one which has for many years been in operation on those lines with most satisfactory results. A change has, however, been made in the arrange-

ment of the lamps, which latter M. Maroni, the chief of the telegraphic and lighting department of the railways of Upper Italy, has materially improved, obtaining both a more intense and softer light, and also a better distribution of the light in the compartments than exists on the Belgian lines. We shall hereafter describe in detail the lamp just referred to, and to which M. Maroni has given his name. The lighting apparatus employed on the direct trains above referred to consists :—

First, of a reservoir of sheet iron containing the gas under a high pressure, this reservoir being placed in the brake van, and being provided with the necessary fittings, such as pressure gauge, pressure reducing apparatus or regulator, &c.

Second, of a very simple system of pipes carried along the roofs of the carriages ; and

Third, of the lamps, which are made movable, that is to say, they can be removed just like the ordinary oil lamps, an arrangement which is very convenient as it enables them at any time to be replaced by the ordinary lamps without inconvenience if circumstances should render it desirable.

The gas employed is a rich cannel gas obtained from the distillation of boghead coal, and it is stored at a pressure of seven atmospheres or about 103 lb. per square inch. There can also, if desired, be employed a gas obtained from hydro-carbon oil, or from the other products resulting from the distillation of fatty matters. The Compagnie de la Haute Italie manufacture their own gas in a small works located at the Turin station, and which, from the relative simplicity of its details as well as on account of the special features in its arrangements, deserves a brief description here.

At the gasworks at Turin two chief operations are performed, namely, the manufacture of the gas and the charging with it of the reservoirs carried by the trains. The general arrangement of the gas-making plant is shown by Figs. 1, 2, and 3 on Plate CLV. The distillation is carried on in the usual way in two benches, each provided with a cast-iron retort, 4 ft. 3 in. long and 8⅝ in. wide by 8⅝ in. high inside, these retorts being made of metal 1·18 in. thick, and being placed in ovens lined with firebrick. In Figs. 1 and 2, A, A, are the retorts ; G the fire-grates ; B, B, the flues for the circulation of the products of combustion, and D the fire-brick lining. The two retorts are set so as to be quite independent of each other.

The product of distillation of the bog-head coal on leaving the retorts are conducted to the hydraulic main K, a pipe L, connected with which leads off the tar, while the gas passes away by another pipe L, to the purifier R, N. In the purifier the gas is subjected to the action of eight layers of quicklime, each ⅝ in. thick, the vessel being divided by a vertical partition, so that the gas is made to traverse four layers in ascending and four in descending. The purifier is of wrought iron, and it is provided with a cock Q, Fig. 1, by means of which any liquid matters deposited may be drawn off. From the purifier the gas is conducted to the gas-holder, where it is stored. As will be seen from what we have said, the process of gas-making adopted is characterised by no special features, and it is unnecessary therefore that we should enter into further details concerning it.

Fig. 3 on Plate CLV. shows the general arrangement of the small gasworks, of which we have been speaking, the building being divided into two parts by a thin brick partition. In this figure A, A, are the benches of retorts ; B, the purifier, and D, the gas-holder. Close by also are the appliances for compressing the gas, which we shall describe hereafter, and of which the chief is the horizontal compressing pump F, which is driven by a small vertical engine with two cylinders placed at L, and supplied with steam from a vertical boiler situated at M. It would doubtless have been preferable to employ for the motive power a small semi-fixed engine and boiler, but the arrangement just mentioned was adopted, as it enabled machinery in stock to be utilised.

During the operation of compressing the gas and filling the reservoirs the vans containing the latter are brought upon a line of rails passing in front of the works, as shown at P, in Fig. 3, the gas being led to the reservoir to be

filled through a connecting pipe I′, of lead or india-rubber. The small reservoirs G, G¹, H, H¹, Fig. 3, are provided for purposes which we shall explain directly.

The compressing apparatus consists of a horizontal double-acting pump constructed on the system of M. Calladon, of Geneva ; Fig. 17, Plate CLVI., being a side elevation of this pump, while Figs. 18 and 19 are respectively an end elevation and a longitudinal section of the barrel. The gas to be compressed enters the pump at A, Fig. 17, the suction valves being situated at *a*, and the delivery valves at *b*, Fig. 18, while the compressed gas is led off at B. During the action of the pump this latter pipe becomes much heated, and to avoid ill effects, it is enclosed by M. Calladon in a reservoir C, Fig. 17, through which cold water constantly circulates. The chief peculiarity in this pump, in fact, consists in the arrangements for preventing overheating, the body of the pump and even the piston rod, being constantly cooled by a current of water. The manner in which this is effected is as follows :—The water leaving the tank C, enters at D, Fig. 18, into the jacket surrounding the pump barrel, while from this jacket it passes off through the pipe E, which is connected by an india-rubber tube with the nozzle F at one end of the piston rod. The latter is made hollow, and the water entering it at F, passes down a copper pipe led along its centre nearly to the other end, as shown in Fig. 18, Plate CLVI. The water is thus made to pass the whole length of the piston rod, while it returns through the annular space surrounding the copper pipe to an exit nozzle at G, whence it is led away by another india-rubber tube, which discharges it into the tank of the gas-holder. It will be seen from what we have just stated that all the important parts of the compressing pump, with the exception of the piston, are maintained at a moderate temperature by the circulation of water, a feature which materially conduces to economical maintenance.

If the gas was drawn by the pump direct from the gas-holder there would be a chance of inconvenience arising in the event of a want of tightness of any of the joints of the pipes allowing the entrance of the water from the shaft E, Fig. 3, Plate CLV., through which they pass, while the length of the pipes also and their small section would tend to retard the flow to the pump and increase the amount of work to be done by the latter. To avoid these inconveniences the gas is drawn by the pump from the cylindrical wrought-iron reservoirs A, A¹, Fig. 4, Plate CLV. In this figure B, is the pipe through which the gas is led from the gas-holder to the reservoirs, while C, C¹, are the pipes through which it is drawn off from the latter by the pump, the admission of the gas to or its exhaustion from, the reservoirs being controlled by the cocks F, F¹, and D, D¹, respectively. It should be added that the two reservoirs are never both in use at the same time, one being always reserved in case of accident. The reservoirs are fixed against the wall of the building, by ring brackets and other supports as indicated in Fig. 3, Plate CLV.

The gas after leaving the compressing pump is not delivered direct into the reservoirs of the guard's van, but passes in the first place into one or the other of the two reservoirs situated at H, H, Fig. 3, Plate CLV. These reservoirs are of wrought-iron 3 millimetres (0·018 in.) thick, and their arrangement is shown by Fig. 5, Plate CLV. They are of a similar form to the reservoirs on the suction side of the pump, of which we have already spoken, and they each consist, as shown, of a cylindrical portion $9\frac{13}{16}$ in. in diameter by 2 ft. $7\frac{1}{2}$ in. long, provided with hemispherical ends, the whole being double riveted. As we have already pointed out, there are two of these reservoirs, but one only is in use at a time, the other being kept in reserve.

To explain the mode of working this apparatus, let us suppose that it is desired to charge the right-hand reservoir C, Fig. 5, Plate CLV. To commence with, the high-pressure cocks *a′*, *b′*, *c′*, and *d′*, are closed, and the gas arriving from the compressing pump through the pipe A, passes through the pipe B, and the cock *a*, into the reservoir C, where it deposits the liquids produced by its compression. Then the cock *b* being opened, the gas, freed from the deposited matters, passes off through the pipes D, E, and F, the latter passing through the wall of the works and joining the flexible tube through which the gas is led to the reservoir in the van, as shown in Fig. 3, Plate CLV. Upon the pipe E, E, Fig. 5, Plate CLV., is fixed a Bourdon gauge, G. As soon as this gauge indicates the maximum pressure which it is desirable to

give to the gas stored in the reservoirs in the van, the cock *a*, is closed, and then *c* and *d* opened. The cock *d* is fixed on pipe H, H, which extends to the bottom of the reservoir C, as shown, while its extension K, extends to the wrought-iron tank I. The tar and other liquid products separated by the compression of the gas are by the pressure of the latter (this pressure being six or seven atmospheres) forced up through the pipes H, K, and discharged into the receiver I. The cock *c* when opened places the reservoir C, in communication with the pipe L, this pipe being led off to join that marked E in Fig. 4, Plate CLV. Any superfluous gas contained in a reservoir in the van can pass back through the cock *b*, Fig. 5, into the reservoir C, and thence by L, Fig. 5, and E, B, Fig. 4, into the bell of the gasholder. Finally operations are terminated by closing the cocks *b*, and *d*; *c* may remain open without causing inconvenience. Knowing the use of the various cocks, &c. belonging to the reservoir C, the mode of employing the corresponding parts of the other reservoir C′, will be readily understood.

We have now to speak of the manner in which the trains are fitted up. The four essential parts of the system are :—(1.) The reservoirs and their accessories. (2.) The pressure regulator. (3.) The pipes and conductors; and (4.) The lamps. These parts we shall describe in the order in which we have mentioned them.

First, then, as to the reservoirs and their fittings. These reservoirs are arranged in a compartment specially reserved for them in the brake van, as shown in Figs. 6 and 7, Plate CLV. This compartment is very confined, its length (in the direction of the length of the vehicle) being but 3 ft. 7⅜ in.; it extends, however, the whole width of the van. It is closed by the wooden partition U, Fig. 7, Plate CLV., this partition being fitted with windows through which the pressure gauges can be seen. These windows are fitted with sliding shutters.

The gas reservoirs in the train are two in number, and they are placed one over the other, as shown at A, A, in Figs. 6 and 7, Plate CLV. They are each 2 ft. 5⅝ in. in diameter inside and 7 ft. 2⅝ in. long over all, while the contents of each is 29·9 cubic feet. The form of each is, as will be seen from Fig. 6, a cylinder terminated by spherical ends. The reservoirs are made of wrought-iron plates 0·275 inches thick, the joints being all double riveted, and they are intended to be charged at a pressure of seven atmospheres effective or 103 lbs. per square inch.

The two reservoirs are connected by a copper pipe C′, Fig. 7, furnished at its two ends with the high-pressure cocks D and D′. The construction of these cocks is shown by the enlarged section of one of them given in Fig. 8. From this it will be seen that the cocks have a screw plug turned by the spindle A, and that an india-rubber packing ring is introduced at E to prevent leakage.

From the pipe C′ is led off the branch C (Fig. 6, Plate CLV.), which is led through the floor of the van, and carries at its outer end a gun-metal cock B. This cock is furnished with a screwed union, and to it is attached the pipe through which the compressed gas is supplied to the reservoirs. When the latter have been filled, the cock B is of course closed. A small copper pipe E, connects the pipe C with a Bourdon pressure gauge fixed at F, while another copper pipe G, is led off from C′ to the pressure regulator H, the construction of which we shall describe directly. While speaking of the arrangement of the parts in the van, we should also mention that the roof of the latter is pierced with openings S, through which the gas can escape freely in the event of any leakage taking place.

We have now to describe the pressure regulator, which is shown in detail by Figs. 9, 10, and 11, Plate CLV. It is constructed on the Borquillon system, known from its application to portable gas apparatus, &c., and it is composed essentially of a brass circular receiver, 5½ in. in diameter, closed on the upper side by a hemispherical cover. This receiver is divided into two parts by a diaphragm of india-rubber impermeable to gas, this diaphragm being, by means of the two iron plates C, weighted so as to be in equilibrium with a pressure of gas corresponding to 1·259 in. of water, at which pressure the gas is supplied to the burners. The middle of the diaphragm is connected, as shown, with the lever D, this lever turning on a fulcrum at *a* and acting on

the pressure-controlling valve E (see Fig. 11, Plate CLV.). The action of the apparatus scarcely requires explanation. Of course if the pressure in lower part of the receiver below the diaphragm becomes increased beyond that to which the diaphragm is weighted, the latter rises, and in doing so closes to a greater or less extend the valve E. If, on the other hand, the pressure falls below the normal amount, the contrary action takes place. Of course the pressure at which the gas is supplied to the burners can be readily varied by modifying the loading of the diaphragm. The only inconvenience attendant upon this apparatus is that which results from the gradual wear of the diaphgram and consequent alteration in its elasticity; this necessitates its examination from time to time. The low-pressure gas is led off from the regulator to the burners through the pipes N, Figs. 9, 10, and 11, Plate CLV., while the cover I of the regulator is furnished with a nozzle L, Fig. 11, to which is attached a pipe leading to the external air. This pipe is marked K, K, in Fig. 6, Plate CLV.

Referring now to Figs. 6 and 7, Plate CLV., it will be seen that the gas from the pressure regulator is conducted through the pipe L, L, provided with a cock M, to another pipe N, which extends along the roof of the van. By means of the cock M, which is operated by a key carried by the guard, the supply of gas to the whole train can be regulated, and it is found that a notable economy is effected by turning down the lights at such times as the train is not traversing tunnels. A branch from the pipe L is led to the water gauge O, which enables the pressure existing in the supply pipes to be at all times ascertained. The pipe N, which is led along the top of the train, is of wrought iron, and is 0·79 in. in diameter.

The gas is conducted along the roofs of the carriages by a simple india-rubber pipe distended by an internal spiral wire, each carriage having its own length of piping. This roof-pipe, as it may be called, is in turn jointed at each lamp where it is attached by means of a simple wrapping with copper wire to the ends of a short length of brass pipe U, T, V, Figs. 12 and 14, Plate CLV., this pipe having a branch leading to the lamp. This mode of making the connexions with the lamps is less elegant than the arrangement of joints employed on the Cambrelin system, but it has the advantage of being very cheap, while it is found in practice to answer all the purposes of a more elaborate arrangement.

The lamps employed are, as we have already stated, the invention of M. Maroni, the *chef de service* of the railways of Upper Italy, and they are very well adapted for their purpose. From a description of his lamps published by M. Maroni, we give the following particulars. Each lamp is made of thin sheet iron, and its body, which is cylindrical in form, is of such diameter as to fit the holes in the roof provided for the ordinary oil lamps; this enables the gas and oil lamps to be used indifferently in the same vehicles, as the exigencies of the traffic may require. Referring to the detail views of M. Maroni's lamp, given in Figs. 12, 13, and 14, Plate CLV., it will be seen that it consists of three principal parts, namely, the cylindrical body E, which fits the opening in the roof; the ground glass globe A, which surrounds the flame and descends below the level of the roof of the compartment; and third, the cover, which serves also as a chimney, and is provided with openings for the admission of air.

When the cock S, situated on the roof of the carriage, is opened the gas passes through the brass pipe Q, B, Fig. 13, to a steatite burner placed as shown. The glass globe is held by three screws *c*, *c*, *c*, and is fixed sufficiently firm to prevent its being disturbed by the motion of the carriage. The openings between the supporting arms are completely closed by a turned iron disc D, which is employed to protect the flame—which is very small—from the action of any violent currents of air, and also to prevent access to the flame being obtained by the passengers, from the interior of the compartment.

The cylindrical body of the lamp is pierced with holes to facilitate the draught, and also to render the compartments free from any smell arising from the combustion of the gas. The cover of the lamp is, as will be seen, movable, being hinged at K, while it can be secured when closed by the catch M, and is fitted with a chimney I, to discharge the products of combustion. It also carries a reflector G, Fig. 13, which assumes its proper position above the flame when the lamp is closed. The lighting of the gas is effected

by opening the cover of the lamp. As will be seen from the views we give, the top of the globe is, when the lamp is in place, about an inch below the roof of the compartment and the latter is thus effectually lighted.

We may add here that the direct trains between Turin and Modane, to which the system of lighting above described is applied, consist generally of eight or nine carriages, each with three compartments, and from the nature of the traffic, carriages are neither added to, nor taken off the trains at intermediate stations. For this reason it has not been considered necessary to retain the auxiliary reservoirs, nor the pipe couplings, which form features in the Cambrelin system. The cost of fitting up the apparatus on the railways of Upper Italy is as follows :—

I.—Cost of fitting up Luggage Van with Reservoirs, &c.

	£	s.	d.
2 reservoirs of wrought iron	16	0	0
1 cock for filling pipe	0	12	0
2 high-pressure valves for reservoirs	1	4	0
1 Bourdon gauge	1	4	0
1 pressure regulator (Bocquollon system)	1	12	0
1 cock for controlling the gas delivery	0	5	9
1 water gauge	0	2	3
19 ft. 8 in. of copper pipe (at 3 francs per metre)	0	14	5
4 ft. of smaller copper pipe	0	1	6
18 ft. of wrought iron pipe for roof	0	4	4
4 ft. „ „ (smaller size)	0	0	9
4 ft. 3 in. of india-rubber pipe	0	7	10
1 copper connecting pipe	0	2	4
Bolts, fastenings, &c. (88 lbs.)	0	19	3
Wood for supports of reservoirs, &c.	0	11	3
Labour and miscellaneous	2	10	4
	26	12	0

II.—Cost of fitting up a Carriage with three Compartments.

	£	s.	d.
Three lamps on the Maroni system (complete)	5	8	0
19 ft. 8 in. of india-rubber tubing	1	16	0
	7	4	0

We have already stated that the reservoirs contain the gas obtained from the boghead coal, compressed to a pressure of seven atmospheres, and that the gas is supplied to the burners at a pressure of 32 millimetres (1·26 in.) of water. Under these circumstances the consumption of each burner is from $1\frac{1}{2}$ to $1\frac{1}{2}$ cubic feet per hour, and the photometric power of each burner is equal to 12 candles, so that ample light is obtained for reading in all parts of the compartment. The flame is small, from $1\frac{3}{8}$ in. to $1\frac{5}{8}$ in. high; and the light soft and agreeable, while from the arrangement of the lamps there is no heating of the compartment. Each train, we may add, is accompanied by a man specially told off to attend to the gas apparatus.

The current expenses of carrying out this system of lighting by gas for the period of one month have been furnished to us as follows:—

I.—Production of the Gas.

	£	s.	d.
327½ cubic feet of boghead coal	7	1	4
Coke for heating retorts	6	13	0
Labour (one man)	3	3	3
9 lbs. of moss for the purifier	0	0	3
44 lbs. of lime „ „	0	0	6
	16	18	4

Quantity of gas produced = 12,820 cubic feet, and the cost therefore was 26*s.* 4*d.* per 1,000 cubic feet.

II.—Cost of Compression.

	£	*s.*	*d.*
Coke for the steam boiler	4	5	1
Wood for lighting fires	0	6	6
Labour (one engine-driver)	4	4	0
Oil for engine and pump	0	4	7
Cotton waste	0	3	0
Packing for stuffing-boxes	0	4	0
	9	7	2

The cost of compression was thus :
About 14*s.* 7*d.* per 1,000 cubic feet compressed.

III.—Cost of Distribution.

	£	*s.*	*d.*
Salaries of three gasmen (30 days each)	12	12	0
Spirits of wine for lighting lamps	0	0	9
India-rubber and leather washers for high-pressure cock	0	0	5
	12	13	2

The cost of distribution was thus at the rate of 19*s.* 9*d.* per 1,000 cubic feet.

The cost per 1,000 cubic feet used may thus be enumerated as follows :—

	£	*s.*	*d.*	
Manufacture	1	6	4	
Compression	0	14	7	
Distribution	0	19	9	
Total	3	0	8	per 1,000 cubic feet consumed.

Each 1,000 cubic feet we may add will suffice on the average to supply 28 burners for a period of 25 hours.

In concluding our notice of this system of lighting we may congratulate M. Amilhau the Director-general of the Compagnie de la Haute Italie, on the success with which he has introduced this mode of lighting the international trains through the Mont Cenis tunnel, and on the additional comfort he has thus afforded to the passengers over his lines. We have also to acknowledge our indebtedness to Mr. F. Kossuth, C.E., for having furnished us with particulars and data concerning this mode of lighting, while finally we may direct attention to a memoir on this subject written by M. O. Lattes, an engineer of Turin, which will be read with interest by those having the lighting of railway trains under their charge.

France.

France was during the earlier days of the Exhibition represented, as regards railway rolling stock, solely by the admirably fitted ambulance trains of the French Rolling Stock Construction Company, of Ivry, a train which we shall describe in due course. Some time after the Exhibition had been opened, however, there arrived three carriages from Messrs. Chevalier, Cheilus jr., and Co., of Paris, two of these being a pair of post-office vans for the Paris, Lyons, and Mediterranean Railway, and the other a first-class carriage of somewhat peculiar construction. The post-office vans were both six-wheeled vehicles fitted up with all conveniences for sorting letters, and lit from the roof. The under-frames were of wood, and were of very light design, while the workmanship generally was very good.

The first-class carriage was a four-wheeled vehicle with three compartments, its chief features being that the compartments only occupied about three-fourths of the width of the body, the remaining space on one side being occupied by an open sided gallery extending from end to end, the floor of this gallery being level with the bottoms of the soles. The roof extended over this gallery, and the latter was protected by an iron railing in the outer side, there being an opening in this railing opposite the door of each of the compartments. At the ends of the gallery were flaps to form a connexion with the next carriage. The compartments of this carriage which were rather low; each carried six passengers, and the seats were made to draw out to form sleeping accommodation. The frame of the carriage was of the composite type, the draw-bar was continuous, and the buffers and draw-springs were of india-rubber.

We come now to the consideration of the sanitary train exhibited at the Vienna Exhibition by the Société Française de Secours aux Blessés, and constructed by the French Rolling Stock Construction Company, at Ivry, a company of which M. Ch. Bonnefond is the manager, The train which is illustrated on Plates CLVI. and CLVII., was composed of eight vehicles, namely:—

1. Depôt wagon containing drugs, linen, wrappers, mattresses, stretchers, surgical instruments, and accessories. (Figs. 1, 2, and 3, Plate CLVII.)
2. A carriage to accommodate four doctors. (Figs. 4, 5, and 6, Plate CLVII.)
3. A cooking wagon. (Figs. 7 to 9, Plate CLVII.)
4. A store wagon, for wine, food, and fuel. (Figs. 13 to 16, Plate CLVI.)
5. Four wagons for wounded, instead of 20, representing the full complement of the train, the four showing, however, the various changes that can be made in the vehicles, according to requirement. (Figs. 10, 11, and 12, Plate CLVII.)

The carriages are all arranged with end entrances, with a central passage from end to end, so that a means of circulation throughout the train is provided, platforms being furnished at both ends of each vehicle to complete the communication.

The depôt wagon, shown by Figs 1, 2, and 3, Plate CLVII., contains, as just stated, all the materials required by the doctors and surgeons, with mattresses, blankets, &c. Besides the end doors, this car has two side doors for the entry or removal of stores, the end openings being only employed for communication. The interior arrangement is extremely good, the stores being placed in drawers and other suitable receptacles, all being thoroughly classified and numbered in such a way that immediate access to any of the contents can be obtained. A desk for the storekeeper is placed beside one of the side entrances. Both desk and seat are made to slide, and are upon hinges, so that they can be instantly removed when access to the vehicle from that side is desired. A small recess in one of the corners of the car, and sheltered by a curtain, forms the bed of the storekeeper. The end platforms are lighted by means of a lantern placed at each extremity under the roof, and the interior of the car is illuminated by means of two ordinary roof lamps. The end doors can be locked both from inside and outside by means of a key which serves for each vehicle in the train.

The doctors' carriage, shown by Figs. 4, 5, and 6, Plate CLVII., is fitted up with much taste and luxury, and is applicable under ordinary conditions as a special saloon car. The interior is divided into six distinct compartments, namely, four separate rooms for the doctors, a watercloset, and a small closet containing the warming apparatus. These compartments are arranged symmetrically on each side of the carriage, so that a clear passage is left down the centre. Each of the four apartments is fitted with a bed, and serves at the same time as a workroom. On one side of the car is hinged a small table, fitted with writing materials, &c. There are besides two chairs, which can be opened, and converted into a comfortable bed. Each compartment contains a suspended moderator lamp, an aneroid, a thermometer, and an alarum clock, and to each door is attached the name of the occupier, and a notice of the hours during which he is on duty.

The heating apparatus is upon a new system, that of Girandeau and Talibert. This apparatus is cylindrical in form, containing a fireplace as its lowest part, and a reservoir of water above, connected with a series of circulating tubes laid under the floor of the car. A small pipe led from the reservoir into the tanks supplying the lavatories, slightly warms the water used to supply the latter.

The kitchen carriage, shown by Figs. 7 to 9, Plate CLVII., has been arranged with very considerable care. It contains a stove suitable for cooking for from 400 to 500 persons, and of course is provided with all necessary utensils, which are carefully secured in their proper places, so that they shall not be disturbed by the oscillation of the vehicle when in motion. In each corner is a large reservoir for water fed from a pipe led up to the roof. Beneath the reservoirs are cupboards holding table utensils, and beside the reservoirs are large copper basins for washing up these utensils.

The interior arrangement of the store wagon shown by Figs. 13 to 16, Plate CLVI., corresponds somewhat with that of the depôt car. It contains drawers to hold a large number of bottles, a coal chest, cases for bread, meat and ice safes, and suitable hooks for suspending carcases, &c. This vehicle has also two side doors to permit of the ingress and egress of goods.

The four hospital carriages—of one of which views are given in Figs. 10, 11, and 12, Plate CLVII.—are arranged as follows:—One with superimposed berths for the wounded, one with seats for convalescents, one dining-room car, and one filled with suspended stretchers. Each of these vehicles can be easily and quickly transformed to any of the above-mentioned forms. They can be employed as ordinary freight wagons, having side doors; they are peculiar, however, in being made with double walls in order to preserve an equable temperature within the car, while part of the space is employed to stow away the benches forming seats for convalescents. The beds are arranged in two or three tiers, the maximum number being 15. They consist simply of wooden frames, and sacking carrying the mattress; the frames are attached to hooks in the side of the car, and to suitable posts, reaching from the floor to the roof, but which are very easily removed. Each wagon has a heating apparatus and water-closet, and the lighting is effected by the lamps attached to the post carrying the beds. Sliding doors serve to give free admission to stretchers, on which wounded patients are placed.

The dining car contains six tables, the legs of which are locked to the floor, but arranged so as to be easily removed. The tables give accommodation for 30 or 40 persons. In the convalescent car the floor area is occupied with seats that can be easily shifted, and, as already stated, stowed away in the space between the double walls of the vehicle. The fourth hospital wagon exhibited showed, instead of fixed berths, the mode of suspending stretcher beds to ropes depending from the roof.

Each complete train of 24 carriages includes only two special vehicles, the doctors' and the kitchen carriages; the others may be employed as common freight wagons in time of peace. The doctors' carriage, however, may, as already stated, be employed for special purposes in ordinary traffic.

This train formed the most conspicuous feature in the pavilion of the Geneva Convention at Vienna, and the merits it possessed were duly acknowledged by the award of a Grand Diploma of Honour made by the jury, but it must be admitted that admirable as all the arrangements were, in absolute practical utility they were not equal to the German ambulance trains. The French showed specially built vehicles, which could easily be adapted for ordinary traffic, the Germans exhibited common wagons, fitted up somewhat roughly, it is true, but in an essentially practical manner. Of the superior comfort afforded by the French arrangements, especially to the surgical staff, there was no doubt, but the German carriages exhibited were either facsimiles of those fitted out during the war, or were based upon the cruel experiences gained during that time. It is true that the French had equal or greater opportunities of gathering similar experiences, and these must have proved to them that, however desirable special and well equipped ambulance trains may be, hospital cars extemporised out of any available rolling stock are also absolutely necessary.

Neither England nor America exhibited any examples of railway rolling stock at Vienna, a matter much to be regretted, as the railway carriage builders of the former country have a deservedly high reputation for high class workmanship, while the double bogie rolling stock of American railways is characterised by numerous special features, which deserved to have been represented amongst such a collection of railway *matériel* as was to be found at Vienna.

We have now completed our review of the railway rolling stock shown at the Vienna Exhibition, and in conclusion we have only to express a hope that the descriptions we have given will have placed the reader in possession of all the leading facts to be gleaned from the numerous exhibits in the class of which we have been treating.

MARINE ENGINES.

In consequence, probably, of Austria being almost entirely an inland country, the number of exhibits to be noticed under this head is but small. There is no great scope for developing any steamship trade in Austria itself, except on a few of the larger rivers, and exhibitors from England and other countries where marine engines are largely manufactured did not care, therefore, to send their goods for show to a place where the market for them was so limited. Among the exhibits at Vienna, however, there were several presenting points of special interest, and these we shall describe fully.

America was entirely unrepresented in this class, while from England, which has long taken the lead in this branch of engineering, the only exhibit was a beautifully finished model of the engines of the "Minotaur," sent by Messrs. John Penn and Son. France was another nation which was unrepresented in this section, while from Belgium there was but one exhibit, namely, a well-built pair of oscillating paddle-wheel engines, constructed by the Société John Cockerill, of Seraing. These engines were erected in the Machinery Hall with feathering paddle-wheels complete, and they were of plain substantial design and good workmanship; but they were not, so far as we are aware, distinguished by any special features.

In the Swiss section of the Machinery Hall, Messrs. Sulzer Brothers, of Winterthur, exhibited a fine set of machinery for submerged wire rope towage on the system introduced by Baron O. de Mesnil and Mr. Max Eyth, this machinery having been constructed by them for a tug-boat belonging to the Cologne Central Towing Company, and intended for service on the Rhine. This boat is a similar vessel to the "Nyitra" a tug-boat now at work on the Danube, and which was designed by Herr Th. Schwarz, the general director of the company just mentioned. We shall have to speak of the "Nyitra" and her performances presently, when dealing with the Austrian exhibits, meanwhile we shall describe the machinery shown at Vienna by Messrs. Sulzer Brothers.

The arrangement of this machinery is shown by the views on Plate CLVIII. The cylinders are 360 millimetres (14·17 in.) in diameter, by 600 millimetres (23·62 in.) stroke. They are steam-jacketted, both at sides and ends, the steam from the boiler passing through the jacket on its way to the valves. Each cylinder has main and expansion slides of the usual construction, the former being worked by a link motion, and the latter by separate eccentrics. The range of cut-off is from ·1 to ·75 of the stroke, and the expansion can be altered by hand, by means of right and left-handed screws, while the engine is at work. The arrangement of the slide-rod guides is somewhat unique. The expansion eccentric is next the journal, and its rod has a straight lead to the spindle; the gab pin of the link is attached to a long bush, in which the expansion valve spindle works, and is guided, and which itself passes through guides at each end, and drives the main valve spindle by means of a lug on the side opposite the gab pin. The main valve spindle is itself also guided in

the usual manner. Loss of heat by radiation is prevented by very thorough cleading of all the exposed surfaces of the cylinders.

Each cylinder has a separate bedplate bolted on to a flange in front of it, and with this are cast the piston rod guides and the main bearing block. The former are bored out, as will be seen from Fig. 7, Plate CLVIII., and the latter have brasses adjustable in two directions. The bedplates are designed so as to transmit all strains as directly as possible, and thus attain the maximum strength in proportion to their weight. The two frames are tied together by a couple of distance pieces, and the back ends of the cylinders are supported by a cross beam of cast iron, which, together with one of the distance pieces, serves to carry the reversing and expansion gear, &c. The starboard bed-plate carries a bearing (see Fig. 4, Plate CLVIII.) for a countershaft, and the port bedplate takes a heavy A-frame, which has a similar bearing cast upon it, and which reaches also above the deck, where it carries one end of the drum shaft, the other end being supported by a plummer block at the side of the vessel. The manner in which the wire rope is guided to the clip drum we shall explain hereafter, when speaking of the "Nyitra." The particulars of the gearing are as follows:—

Crankshaft pinion, number of teeth	19
Countershaft wheel „	42
Pitch	103 mm. (4·05 in.)
Breadth of teeth	250 mm. (9·84 in.)
Countershaft pinion, number of teeth	24
Drum shaft wheel „	96
Pitch	103 mm. (4·05 in.)
Breadth of teeth	320 mm. (12·59 in.)

Clip drum, diameter, 9 ft.

The exhaust from both cylinders passes through a wrought-iron tubular feed heater, and then through a reversible valve so arranged that the engine can be used either with or without condensation. The condenser is a plain wrought-iron vertical cylinder, the injection water being brought up through a pipe in the centre of it, very much as in Danek's compound engine, described in a former section of this report. The air pump is worked off a prolongation of the port piston rod. The air pump chamber, valve seats, and hot well, are in one casting, and are held at the proper distance from the cylinder by means of a couple of wrought-iron stays. The condensed steam is led into the bottom of the casting, below the suction valves, Fig. 3, and pumped upwards into the hot well. The feed pumps are fixed to brackets cast with the piston rod guides, and are worked direct from the ends of the crosshead pins by wrought-iron plungers.

The following dimensions and particulars supplement those already given:

	Inches.
Diameter of air pump	10
Diameter of crankshaft journals	5½
Diameter of drumshaft outer bearing	9·58

Working steam pressure 100 lb. above the atmosphere.

Revolutions of crankshaft per minute 80 to 120 (maximum 150).

The engines seem thoroughly well designed; they are massive without waste of metal, the workmanship also is very good. The crankshaft, countershaft, and drumshaft are all of steel, as well as the piston rods, crosshead pins, valve spindles, &c. It will be noticed that the whole of the hand gearing is arranged so as to be conveniently under the control of the engineer when standing behind and between the cylinders.

Messrs. Burmeister and Wain, the largest engineers and shipbuilders in Copenhagen, a firm employing about 1,200 hands, exhibited in the Danish section a pair of compound marine engines of 30 horse power nominal, the design of which was in several respects novel. There were two high-pressure cylinders on the top of the low-pressure cylinders, but the latter had trunks so that the total height of the engines was not more than would be occupied by

ordinary direct-acting engines without the extra cylinders above. Each low-pressure cylinder had one of the side frames cast on it, and in several respects much trouble seemed to have been taken to reduce as much as possible the number of pieces in which the engine is made. The engines had a horizontal cylindrical surface condenser, the pumps being worked by levers connected with the lower ends of the trunks. Engines of similar construction have been made by the same firm from 16 up to 400 horse power. Messrs. Burmeister and Wain also exhibited photographs of various other marine engines of their own manufacture, and drawings and models of different vessels.

Sweden was represented in this branch of engineering by the Motala Works, a pair of compound engines for a twin screw gunboat being shown by this firm in the Machinery Hall, while a complete little passenger steamer constructed at the same works was during the period of the Exhibition shown on the "regulated" Danube.

The twin screw engines from the Motala Works are illustrated by us on Plate CLIX., and, as will be seen from the engravings, they are of the horizontal, compound intermediate receiver type, the pistons of each pair of engines driving cranks at right angles. The positions which the two pairs of engines occupy with regard to each other is clearly shown by the plan Fig. 1. The dimensions on the engravings, we may add, are in Swedish feet and inches, but the principal dimensions in English measures are as follows :—

	ft.	in.
Diameter of high-pressure cylinder - -	0	10·96
„ low „ - -	1	9·92
Stroke of both pistons - - - -	1	5·53
Diameter of air pump - - - -	0	7·3
Stroke „ - - - -	0	8·77
Diameter of crankshaft - - -	0	4·62
„ high-pressure piston rods - -	0	2·4
„ low „ „ - -	0	2·7

The cylinders are well cased with a non-conducting composition, but are not steam jacketted. The intermediate receiver is of very large capacity—too large we consider—and it encircles the high pressure valve chest, as shown in the section Fig. 4, Plate CLIX., the high-pressure cylinder also being partially exposed to the influence of its own exhaust steam. Both cylinders are fitted with ordinary slide valves driven by link motion, both valves having 0·24 in. inside lap, and 3·4 in. stroke in full gear. The high-pressure valve has an outside lap of 0·83 in., and the low-pressure valve of 0·85 in., the former cutting off at three-fourths, and the latter at seven-ninths of the stroke when working in full gear. The steam ports of both cylinders are 1·46 in. wide, those of the high-pressure cylinder being 5·84 in., and those of the low-pressure 10·7 in. long. The link motion is of a simple pattern, and its arrangement and that of the reversing gear will be readily understood from Figs. 1, 2, 5, and 6, Plate CLIX.

The engines are fitted with injection condensers, as shown in the section Fig. 5, and the exhaust pipe is led to the condenser from the top of the low-pressure valve chest, as shown in Fig. 2. This latter figure also represents the air-pump, which is single acting, and is driven from an eccentric on the crank-shaft through the intervention of a rocking lever as shown.

The engines are worked with steam at 60 lb. pressure supplied by two boilers of the pattern shown by the outline diagram Fig. 7, Plate CLIX., the principal dimensions of each of these boilers in English measures being as follow :—

	ft.	in.
Diameter of boilers - - - -	6	$7\frac{5}{8}$
Length „ - - - -	7	$11\frac{1}{2}$
Diameter of furnace (one in each boiler) -	2	$9\frac{1}{2}$
„ tubes (brass) outside - -	0	2·56
Length of tubes between tube plates - -	5	$10\frac{1}{5}$
Diameter of safety valves (two to each boiler) -	0	3·4
„ steam pipes - - -	0	3·4

	Square feet.
Heating surface :	
Furnaces - - - - -	54
Combustion chamber - - - -	76·4
Tubes (outside) - - - -	798·7
Tront tube plate - - - -	17
Total - - - -	946·1
Firegrate area - - - -	26·6
Area of water surface - - - -	94
	Square inches.
Sectional area of ash-pit - - -	786
„ at fire-bridge - - -	723
„ of tubes - - - -	854
„ of chimney - - -	843

The engines exhibited were similar to those constructed at Motala for the Royal Swedish gunboat "Ulf," and on a trial made on the 25th of October 1873 the two pairs of engines of the "Ulf" developed together 160·27 indicated horse power with a consumption of 386 lb. of coal per hour, thus giving a consumption of 2·4 lb. of coal per indicated horse power per hour. We give on Plate CLX., Figs. 10 to 13, reproductions of some indicator cards taken from these engines, the circumstances under which they were taken being stated on the diagrams. The cut-offs in both cylinders at the time these diagrams were taken were too late to show an advantageous performance, but even with an earlier cut-off in the high-pressure cylinder we doubt if the cut-off in the low would be sufficiently early to give the best results. With a late cut-off in the low-pressure cylinder the effect of an excessively large receiver is of course aggravated. The engines shown at Vienna were of very neat design, and the workmanship was excellent.

We have now to speak of the second exhibit from the Motala Works, namely, the small passenger steamer. Visitors to Stockholm are all familiar with the small passenger steamers which the position of that city enables to be used with so much convenience to the public, and the demand for these boats has led to considerable attention being paid to the design of simple engines for driving them. The "Motala," the boat just referred to, was an excellent specimen of this class, and the engine by which she was propelled is illustrated by us on Plate CLX.

The principal dimensions of the "Motala" are: Length over all, 56 ft. 6 in.; beam, 11 ft. 8 in.; draught of water with 106 passengers on board, and coal bunkers filled, 4 ft. $2\frac{3}{4}$ in. The engine by which the boat is driven is non-condensing, and is rated at 8 horse power, and its construction is, as we have said, shown by Figs. 1 to 8, on Plate CLX. It has, as will be seen, a single cylinder, and is fitted with an expansion slide working in a separate valve chest to the ordinary slide.

The supply of steam to the engine is controlled by the butterfly valve, of which we give a detailed view in Figs. 5, 6, and 7, Plate CLX., this valve and its casing being formed so that steam can be admitted through the openings *h h* to the expansion valve chest only, or to both the expansion valve chest and the chest containing the ordinary slide, the opening *l* communicating with the latter. This is a handy arrangement, and enables steam to be admitted for nearly the whole stroke at starting, &c., while by covering the port *l* the expansion valve is at once brought into action.

The reversing is effected by means of the arrangements shown in detail by Fig. 8, Plate CLX. From this it will be seen that the two eccentrics, *e f*, are not fixed directly on the crankshaft, but are formed on the sleeve *d*, this sleeve being held between two collars on the shaft, so that it cannot shift longitudinally. Encircling the sleeve *d* is another sleeve *c*, which has a series of collars turned upon it, these collars engaging with the pinion *b*. By turning the handle *a*, Fig. 2, the pinion *b*, Fig. 8, is made to shift the sleeve *c* longitudinally upon the sleeve *d*. Through the sleeve *d* are cut two spiral slots, shown in Fig. 8, and fitting these slots are blocks *h*, these blocks being carried by the outer sleeve *c*, and their inner ends working in straight grooves cut in the crankshaft. It follows from this arrangement that when the sleeve *c* is

shifted longitudinally on *d*, the latter is by the action of the blocks *h* in the spiral slots turned upon the crankshaft, and the eccentrics are thus shifted from the position for going ahead to that for going astern, or *vice versâ*. The arrangement is not a novel one, but the details are very neatly worked out.

The engine is placed abaft the boiler, and close to it, and the exhaust steam after traversing the belt *q* enters the feed-water heater *s*, and passes thence through a pipe attached at *r* into the chimney. The feed-water leaves the feed pump by the pipe *o*, traverses a bent pipe inside the heater, and leaves the latter at *p*, whence it is led off to the boiler. The bilge pump is at *u*, and *t t* are hand pumps.

The engine drives a screw 3 ft. 2 in. in diameter, with 6 ft. 9⅝ in. pitch, and it is supplied with steam at 60 lb. pressure by a boiler of the locomotive type, as shown by the diagram, Fig. 9, Plate CLX. The dimensions in the latter are in Swedish feet and inches. The principal dimensions in English measures are as follow :

	ft.	in.
Diameter of barrel - - - -	3	1
„ tubes - - - -	0	1·95
Length of tubes between tube plates - -	4	2⅛
Number of tubes - - - 46		
Length of firebox casing - - -	2	11
Total heating surface - - 120½ sq. ft.		
Firegrate surface - - 3·8 „		

Figs. 3 and 4, on Plate CLX., show a somewhat differently arranged engine to that above described, this engine, which is also one made at the Motala works, being intended to be placed aft the boiler, and to give a sufficient distance between the engine and boiler for firing the latter. Both the designs illustrated are neat and simple, and well adapted for their purpose.

In the German section we found but one exhibit belonging to the class of which we are now speaking, this exhibit being some machinery for towage by means of a submerged chain, constructed by the Sächische Dampschiffs und Maschinenbau Anstalt, of Dresden. This machinery we illustrate on Plate CLXI., from which it will be seen that in this case the haulage is exerted on a chain by passing the latter round a pair of drums arranged as shown, and driven by a pair of inclined engines.

The engines have cylinders 305 millimetres (12 in.) diameter, by 610 millimetres (2 ft.) stroke, and they are fixed one on each side of the drum framing. The cylinder, guide bars, and plummer block, &c., of each engine are bolted separately to an inclined framing or bed-plate. The crank shaft passes right through the side openings in the drum frames, and is supported by two plummer blocks, carried by the engine frames, as shown. The two drums, which are ridged in the usual way, are keyed on to counter shafts running in bearings on the top of the main frames. The drums are driven by gearing, and they are made to revolve in the same direction and with the same velocity, the proportions of the gearing being such that they make nine revolutions for every 13 revolutions made by the crank shaft.

The whole of the framing is of a rectangular box section, and is very plain and substantial. As for the engines themselves, there is nothing about them requiring special notice, they being of the simplest type, fitted with ordinary link motion. They are provided with an injection condenser, and the air-pump, which is vertical, is driven from eccentrics on the crank shaft, as shown in Fig. 4, Plate CLXI. The principal dimensions of the machinery are figured on the Plate.

The same firm also showed on the "regulated" Danube during the period of the Exhibition a small paddle steamer driven by oscillating engines. These engines had no slide valves, the admission and exhaustion of the steam taking place through ports formed in the trunnions and their casings, and the distribution of the steam being thus effected by the oscillation of the cylinders. This plan has been sometimes used in this country for small engines, but, we need scarcely say, that it is attended with a wasteful distribution of the steam, it being impossible to effect expansion except by throttling. In the engines of which we are now speaking the reversal was effected by a reversing valve, by

moving which the exhaust ports were transformed into steam ports, and *vice versâ*. The engines were very roughly made, but the general fittings of the boat were good.

In the Austrian section of the Machinery Hall the Stabilimento Tecnico Triestino showed two examples of compound screw engines, the smaller pair being rated at 25 and the larger at 140 horse power nominal. The larger pair of these engines is illustrated by us on Plates CLXIII. and CLXIV., and the smaller pair on Plate CLXII. Both engines are, as will be seen, of the vertical compound intermediate receiver type, with surface condensers.

The larger engines have cylinders 31 in. and 60 in. in diameter respectively, with a stroke of 3 ft. They are both steam-jacketted, both at the sides and ends. The working barrels are cast separately, and secured by internal flanges at their lower ends to the main castings, the upper ends are steadied by bearing against bored projections in the main casting, and the annular spaces are made steam-tight by wire-rope packing, as in the smaller engine to be described presently. The high-pressure cylinder has a pair of ordinary expansion plates working upon the back of the main slide, these plates being driven from a pin fixed in the forward end of the crank-shaft. A rod fastened to the lower end of the expansion valve spindle is carried downwards, and connected by bevel gearing to a small hand wheel, and by this means the cut-off can be altered (the valves being fitted with right and left-handed screws) at will while the engine is in motion. An index is provided to show at what grade of expansion the engine is working.

The low-pressure cylinder has a double-ported slide, worked, as is the main valve of the high-pressure cylinder, by an overhung link motion. The port side of the low-pressure cylinder is supported by a hollow cast-iron standard, which rests upon the bedplate, and forms in itself the hot-well and air-pump seating. The same side of the high-pressure cylinder rests upon a bracket cast on the front of the surface condenser, which is cylindrical, and has vertical tubes. The starboard side of the cylinder is supported by a couple of wrought-iron columns. Separate guide plates for the piston-rod heads are bolted to the front of the standards.

The cranks are placed at right angles, and carefully balanced, and the crankshaft, which is 10⅛ in. in diameter, is made, as is now common, without collars. The bedplate is cast in two pieces; the crankshaft bearings are raised somewhat above it, and fitted with wrought iron caps. The air pump is placed behind the after standard, and worked by levers in the usual way; it is single-acting, 26 in. in diameter, and 18 in. stroke. Two feed and two bilge pumps are worked off the ends of the air pump crosshead. A separate pump, unconnected with the engine, is used for the circulating water. The reversing is effected by a handwheel, through a pair of bevel pinions and a vertical worm shaft. A steam stop valve, worked also by a hand wheel, is bolted directly to the high-pressure valve chest, and another valve is provided to admit, when necessary, a small quantity of high-pressure steam into the low-pressure valve chamber.

All the various handles, including those of the pet cocks, are arranged so as to be within easy reach of the starting platform, and the engines seem to be in every respect arranged with a view to accessibility. The balancing of the moving parts—a matter too often neglected—with the complete arrangements for an early cut off, show also that the engines have been carefully designed. While, however, in some matters English engineers would do well to imitate Austrian, in others we think the latter might advantageously alter their designs. Of these the most noticeable is that the engine would be the steadier for the addition of a middle column in front, in addition to the two at present placed there. Another is that the space between the cylinders is far larger than appears to us either necessary or desirable. It is also a question to which we have yet seen no experimental answer, whether a steam jacket can be economically used as a reheater for the steam on its way between the two cylinders. In conclusion, we should state that the engine just described seemed to be well put together, or in common phrase, a "workmanlike job."

The smaller pair of engines from the Stabilimento Tecnico Triestino is, as we have said, illustrated on Plate CLXII. Its cylinders are respectively 13⅜ in.

and 23 in. in diameter, with a stroke of 16 in. The working barrels of the cylinders are made separately from the main castings, and bolted to them by an inside flange on their bottom ends, the upper ends being made so that they can be packed by wire rope packing, kept in place by a wrought-iron ring, a system of construction similar to that adopted by Messrs. Penn. The annular spaces left between the main castings and the barrels form the steam jackets, but not advantageously, on account of the former being, to a greater extent than is necessary, in contact with the exhaust steam.

The valves are placed outside the cylinders instead of between them, and the exhaust from the high-pressure cylinder is carried through a passage partly inside and partly outside the main castings to the valve chest of the low-pressure cylinder. The valves themselves are of the simplest construction, without any arrangement for balancing. Each is worked through a link motion of the ordinary type, the links being suspended in the centre. The arrangement of the reversing gear is very neat, and for such a small engine a horizontal hand wheel will do as well as a vertical one.

It will be noticed that the space between the cylinders, rendered necessary by the arrangement of the pump beneath, forms an intermediate receiver of very large capacity. The section of the passage, however, which connects the receiver with the low-pressure valve chest, is comparatively small. The method adopted for working the air and circulating pumps, though not novel, is neat. A short throw crank is forged on the shaft between the two middle bearings, and this drives a crosshead to which are attached the two feed pump plungers. Rods attached to these plungers are carried over the shaft close to the crank cheeks, and form the rods of the air and circulating pumps respectively. An additional guide is provided for each of these rods besides the two stuffing boxes. The surface condenser is placed above the pumps, hotwell, and valve chambers, and forms a support for the cylinders. The tubes are arranged horizontally, and divided into two sections, so that the water passes once across the condenser in each direction before being discharged.

A weak point about the design is, we think, the way in which the cylinders are supported on the front side. They depend for steadiness entirely upon two light wrought-iron columns placed as far apart as the bedplate will allow them to be, and certainly not strengthened by being made to serve as bearings for the weigh shaft. For such a small engine three columns would no doubt have sufficed, but the air pump connecting rod prevents this, and we think that under these circumstances it would have been wiser to go to the extreme of putting four columns rather than trust to the steadiness of two. We have known more than one case where an engine constructed like the present showed such palpable shakiness, that a middle column had to be added at no small inconvenience and expense. The advantage of wrought-iron columns instead of cast-iron standards, in adding to the accessibilty of the different parts of the engine is, however, incontestable. The engine was neatly made, the work put upon it corresponding, as it should do, to a machine made to go to sea rather than to one made only for show.

It was not in the machinery hall alone, however, that the Austrians were represented by marine engineering. The Donau Dampfschiff-fahrt Gesellschaft had a pavilion to themselves near the eastern end of the main Machinery Hall, and a very interesting series of exhibits it contained. In it were three engines for steamboats complete, of 60, 100, and 150 horse power respectively. All were compound engines, but without surface condensers, as they have only to work in the fresh water of the Danube. The smallest was a screw engine, very neatly finished and balanced, and with a somewhat novel arrangement of the steam receiver between the high and low-pressure cylinders. The screw shaft with its propeller on was attached to the engine, and both this engine and the one next to be mentioned were set in motion by belts from a small auxiliary engine. The 100 horse power engine was an interesting example of a compound oscillating engine, and the arrangement of its condenser and hot well was new; it had its paddle shaft and wheels attached. Perhaps the most interesting engine of the three was the largest. It was a

direct-acting engine with the cylinders set obliquely at only a small angle from the horizontal. Like the oscillating engine it also had its wheels attached, and it was shown in motion. All these engines we should state had been constructed by the company at their own works, from the designs of their chief engineer Mr. Murray Jackson, and they were in every respect most creditable productions.

Besides the large engines of which we have just been speaking, the pavilion of the Donau Dampfschiff-fahrt Gesellschaft contained a most interesting series of models of the various types of vessels owned by the company, a number of these illustrating the different systems of towage carried out on the Danube. Of these arrangements for towage we can here speak of only two, namely, the system of haulage by a clip-drum on a submerged wire rope introduced by Baron O. de Mesnil and Mr. Max Eyth, and already alluded to by us, and another system of hauling on wire rope designed by Mr. Murray Jackson.

The application of Fowler's well-known clip pulley, for the purpose of propelling boats by means of a fixed wire rope, is gradually extending on continental rivers and canals. After the first experiments made at Leeds, by Baron O. de Mesnil, and a series of trials, during the following years, on the Erie, and Hudson, and Delaware canals, in America, several lines were successfully established in Belgium and France. Although some of them, owing to circumstances wholly unconnected with the mechanical problem of wire-rope navigation, have at the present moment ceased to work, the operations connected with this novel application of steam power are daily growing in extent and importance.

As a first step for the extensive introduction of the system on the Danube, the Imperial Austrian Danube Steam Navigation Company caused the construction of a powerful tug of 50 horse power nominal, after the designs of Mr. T. Schwarz, the present managing director of the Central Towing Company, at Cologne. A general description of this vessel will explain the principal features of Baron O. de Mesnil's and M. Eyth's patents.

The "Nyitra" (see engraving on Plate CLXIV.) is a flat-bottomed iron vessel of a total length of 138 ft., beam 24½ ft., and depth of hold 7½ ft. It is provided with two false keels, and has a large rudder at the bow as well as at the stern, each rudder being separately governed by a wheel placed near the centre of the boat. As on most rivers with rapid currents, it is intended to use the wire rope on the Danube only for towing up stream. The tug is therefore provided with twin screws of 4 ft. 2 in. diameter, worked by two separate vertical engines placed near the bow, and supplied with steam by the same boilers, which also work the clip-drum machinery.

The latter consists of a double cylinder horizontal engine with variable expansion and condensation. The diameter of the cylinders is 14$\frac{3}{16}$ in., and the stroke 23$\frac{5}{8}$ in. The two cylinders are mounted on two separate parallel bed-plates, each carrying one bearing of the common crank shaft, and also of an intermediate shaft, placed parallel with the latter, but somewhat higher and nearer the cylinder end of the engines. For the two cylinders there is only one condenser and air-pump, worked by the elongated piston rod at the back of the right-hand cylinder. The bed-plate of the same engine carries a strong cast-iron upright, supporting one end of the horizontal clip-drum shaft, whilst the other end is carried by a bracket firmly bolted to the starboard side of the boat.

A pinion, sliding on feathers on the crank shaft between its bearings, gears into a wheel on the intermediate shaft, which by a second pinion and a large driving wheel keyed to the main shaft above deck, moves the clip-drum. The speed from the crank to the intermediate shaft is reduced in the proportion of 1·8:1, and from the latter to the clip-drum shaft in the proportion of 4·4:1, the reduction altogether being, therefore, in the proportion of about 8:1. The positions of shafts and wheels are further so arranged, that the crank shaft pinion can be made to gear direct into the main wheel of the clip-drum shaft. Thus a second considerably increased speed can be given to the clip-

drum. As the diameter of the latter is 10 ft. 6 in., one revolution of the engine corresponds to an advance of the boat by slow speed gear of 4·1 ft. and by quick speed gear of 7·5 ft.

The clip-drum is keyed to the outside end of the main shaft; it therefore overhangs the port side of the boat, its horizontal centre line being about 1 ft. above the deck. The clips are set to work at $1\frac{5}{8}$ in. wire rope. Two press pulleys can be made to touch the rope, somewhat above the horizontal centre line, of which the hind one at least is required to give to the last clips of the drum the necessary initial bite, whenever the back rope gets unusually slack.

For the purpose of leading the rope from the bottom of the river over the clip-drum, and permitting it to sink down again into the water, there are three large guide pulleys employed, each having the same diameter as the clip-drum itself, viz., 10 ft. 6 in. The first pulley over which the rope passes runs loose on a stud fixed to a wrought-iron bracket, which is provided with two nearly vertical steel pivots. These pivots are held in corresponding bearings, firmly connected with the ship's side. Thus the pulley is able to swing about, very much like a door swinging on its hinges, and will place itself readily in the direction indicated by the wire rope. It will be understood now why the deck near the bow of the ship slopes down towards the water, thus permitting the wire rope to pass over it at any angle without hindrance. To allow for the swinging of the pulley towards the ship, a segment had to be cut out of the ship's side, but this segment is entirely above the water line, and therefore of little importance.

The second pulley, which the rope touches along the underside of its periphery, turns on a stud fixed in the side of the vessel. It is so placed that the centre line of the pivots of the swinging pulley above described is tangential to both pulleys, so that the rope runs perfectly correct from one pulley to the other, whatever the position of the movable one may be.

From this pulley the rope runs over the clip-drum, touching the upper half of its periphery, after which it passes over to the third and last guide sheave. This again is a swinging pulley, with perfectly vertical pivots, its bottom edge reaching below the keels of the vessel. Thus the back rope is allowed to fall to the ground at any angle it may assume towards the centre line of the ship. Here also a segment had to be taken out of the regular side of the vessel, to permit the pulley to swing inwards if required.

Throughout its passage through the pulleys the rope is everywhere carefully guarded against getting out of the grooves when slack. These guards had to be so arranged that they can readily be removed and replaced whenever the rope has to be taken off or put on again. There is finally a small suspended guide pulley near the stern of the boat; but this is generally not used. Only when the boat has to go backward for a considerable distance the wire rope is placed into it, so as to guide the vessel, or rather prevent it from swinging round. The boilers are placed between the clip-drum engine and the screw engines. They are two in number, of a type very commonly employed on river steamers, and scarcely calling for particular description.

The total displacement of the boat, when ready for service, amounts to about 200 tons; the draft is 3 ft. 9 in., the immersed midsection 74 square feet. Besides the machinery, weighing 42 tons, boilers weighing 32 tons, and coal bunkers holding 10 tons, it contains nothing but the usual accommodation for captain, engineers, and crew, and the necessary fittings and contrivances for attaching barges, &c.

We now give an extract from the official report of one of the trial trips, undertaken to ascertain the efficiency of the machinery, and the results gained by the application of the system. On September 2, 1871, the wire-rope tug, Nyitra, started from her anchorage, towing, by means of her auxiliary screws, three barges to the place where the rope, previously immersed, had to be picked up. It was caught up by a grappling anchor, and fixed to the side of the boat, an operation which lasted from 7.5 to 7.44 a.m. Six workmen were required to place it over the guide pulleys and the clip-drum, the operation being performed in 49 minutes.

These operations took far more than the ordinary time, in consequence of one of the buoys which marked the position of the rope having been broken loose. The tug, also, with the three barges in tow, was difficult to handle, whilst the rope, laying at the particular spot very much across the river bed, had to be pulled from underneath it. At former trials, on the 22nd of August, the same operation took only 25 minutes; on the 28th of August, 22 minutes; on the 1st of September, 15 minutes. At the trial trip on the 3rd September, which was undertaken solely to ascertain the steering power of the vessel, the picking up of the rope took 8 minutes, and the placing it into the pulleys 20 minutes. By employing stronger and more suitable blocks for lifting and handling the rope the time for these operations could still be greatly reduced.

The three barges which had to be towed were all of the same construction, being flat-bottomed iron vessels, 180 ft. long, 21 ft. beam, and 8 ft. 4 in. depth of hold.

		decim.		ft. in.
The draught was in boat	A -	- 15	=	4 11
„	„ B -	- 15½	=	5 0
„	„ C -	- 14½	=	4 9

This indicated, according to the official gauging, the following cargoes :—

	cwt.
For boat A -	5,220
„ B -	5,132
„ C -	4,997
Total -	15,349 (German) = 752 tons 2 cwt. (English).

The invoices of the cargoes indicated a total of 16,286 cwt. (German) = 798 tons (English) of coals and wood. But it was ascertained that several hundredweight of coal had been taken out of the boats previous to the trial.

For the purpose of ascertaining the exact speed of the tug, the two end points of the trial course were laid down on the map of the river Danube, edited by the Imperial Government, scale $\frac{1}{288000}$. The distance between Gran and Great Maros, following the line of the wire rope, was found to be 2·824 Austrian, or 13·30 English miles. The time of running over this course was found to be 2 hours 42 minutes 55 seconds. Thus the speed of the boat amounted to 1·040 Austrian miles, or 4·898 English miles per hour.

The current of the river was measured in two different ways; first, on September 2nd by floats, and then on September 3rd by the difference of speed of the steamer Jstvan, whilst going up or down stream, over the whole course. The experiments with floats were undertaken at three different points, the floats consisting of two bottles, connected by a string of 3 ft. 9 in. in length, one bottle going at the depth allowed by the string (which corresponds to the draught of the tug), the other floating on the surface. The observed distance was 36·55 metres for each experiment, and there were ten experiments made at each of the three points selected. The average speeds thus obtained were :

At the lowest point	-	-	-	1·04 metre per second.
„ middle	„ -	-	-	1·384 „ „
„ upper	„ -	-	-	1·636 „ „

but from these figures the average speed of the river was calculated by taking the lowest of the three speeds (which apparently was constant over half the course), twice into account, whilst the other figures were only taken once. Thus the speed was found to be 1·275 metre per second, or 0·605 Austrian, or 2·85 English miles per hour.

The difference of the speed of the steamer "Jstvan" in a trip up and down the river between Gran and Great Maros indicated, by calculation, a speed of the current = 0·594 Austrian miles, showing a difference of only 0·011 mile, with the observations above quoted. 0·600 Austrian, or 2·83 English miles will, therefore, be very near the truth.

During the trial the coal was carefully weighed. At the end of the trip the steam pressure, the water in the boiler, and the fire on the grate, ware as much as possible in the same condition as at starting. The coal consumed amounted to 22 cwt. 73½ lb. (German weight) or 2,506 lb. (English) of small coal from Feldkirch, Hungary.

The slag, clinkers, and ashes, weighed back amounted to 14 cwt. 71 lb., but it must be remarked that the firemen, in spite of orders to the contrary, had used some water to extinguish the fire in the ash-pits, and that, therefore, the residue, when weighed back, was not perfectly dry. At previous experiments and subsequent trials, the proportion of the slag and ashes returned was carefully ascertained. It amounted on August 24th to 45·4 per cent. of the original weight of coal. On September 3rd 2,273½ lb. of coal produced 1,471 lb. of wet ashes, which perfectly dry weighed 1,177 lb., or 50 per cent. of the original coal. September 8th, 545·8 lb. of coal, most carefuliy burnt on a grate, yielded 244·2 lb. of perfectly dry residue. An equal quantity slackened with water in the ordinary manner weighed wet 299·2 lb. It therefore appears fully ascertained that the coal used leaves 48 to 50 per cent. of its original weight of slag and stones.

The coal consumed per hour was, under these circumstances, 837·3 lb. German or 922·7 lb. (English). The coal consumed per Austrian mile was 805 lb. The coal consumed per (German) cwt. moved 1 mile (Austrian) was, therefore, according to invoice 0·0494 lb.; according to measurement 0·0524 lb. This is equivalent per English mile and ton, according to invoice, to 0·214 lb. of coal; according to measurement to 0·222 lb.

The steam gauges indicated, throughout the trip, a pressure of from 66 to 75 lb.; the permissible boiler pressure being 80 lb.

The average number of revolutions of the engine was 105·5. Calculating out of this the distance travelled by the tug along the rope, we find it to be 13·4 English miles. The real distance measured along the same line was shown to be 13·3 miles. The difference of less than 1 per cent. has no doubt to be explained by the slack of the rope.

The steam engine worked with variable expansion, which was altered between $\frac{3}{10}$ and $\frac{5}{10}$ of steam admission according to the varying steam pressure or the current which had to be overcome. The vacuum in the condenser was indicated by a column of mercury, showing throughout a height of 61·4 centimetres=24·17 in.

Indicator diagrams were taken at intervals of 10 minutes, with two indicators, one for each cylinder, after previously ascertaining that the diagrams at the two ends of each cylinder were practically identical. The diagrams showed an average of 134·4 horse-power (indicated). The influence of the curve at the lower end of the course on the towage power required was very striking. In a straight course the tug would have attained a considerably higher speed. The coal consumed per indicated horse power per hour amounted, according to the above figures, to 6·23 lb. (German) or 6·85 lb. (English) of Feldkirch small coal.

Arrived at the upper end of the course the rope was thrown out of the pulleys, an operation which took five minutes. The return journey, with the same boats in tow, down the river, was performed by means of the twin screws, and took two hours and 15 minutes.

In the afternoon the same train of boats was towed over the same course, the boats being attached, as before, to the port side of the tug, the same side on which the clip-drum works. The object of this trial was merely to show the steering power of the vessel in the strong curve between Visegrad and Dömös. It was demonstrated that the tug, even without the use of the bow rudder, steers readily at an angle of 30 degrees against the direction of the wire rope, moving from side to side over one-third of the breadth of the river with perfect ease.

The adjoining table gives the detailed observations during the main trial, we have described above.

OBSERVATIONS DURING TRIAL TRIP.

Time.	Boiler Pressure.	Vacuum Centimetre of Mercury.	Steam Admission in Eighths of Stroke.	Revolutions per Minute.	Indicated Horse Power.	Remarks.
h. m.	lb.	centim.				
8 45	73½	..	2½	..	..	Post passed at 8 hrs. 46 m. 50 sec.
8 50	66½	..	2½	118	..	
8 55	66½	60	2½	..	160·8	
9 0	..	..	2½	119	..	
9 5	67	..	2½	118	154·3	
9 10	..	..	2½	113	..	
9 15	66	..	2½	102	134·1	Middle of curve.
9 20	..	..	2½	109	..	
9 25	59	..	2½	108	130·9	
9 30	..	62	2½	104	..	
9 35	60½	62	2½	98	117·1	
9 40	..	62	2½	108	..	
9 45	69½	61	2½	111	154·8	End of curve.
9 50	..	60	1½	120	..	
9 55	78½	60	1½	112	..	
10 0	..	61	1½	115	137·2	
10 5	76½	60	1½	110	..	
10 10	..	61	1½	108	131·1	
10 15	76½	61	1½	102	121·5	
10 20	..	62	1½	98	..	
10 25	68½	61	1½	102	117·6	
10 30	..	62	1½	98	..	
10 35	71½	61	1½	100	121·4	
10 40	..	62	1½	102	..	
10 45	77	60	1½	107	131·3	
10 50	..	61	1½	109	..	
10 55	72	61	1½	108	128·8	
11 0	..	63	1½	86	..	Current rapidly increasing.
11 5	70	63	2	95	127·1	
11 10	..	63	2	91	..	
11 15	74	63	2	93	130·1	
11 20	..	62	2	100	..	
11 25	75	61	2	106	159·9	
11 30	..	62	2	106	..	Post passed at 11 hrs. 29 m. 45 sec.
Average	70·6	61·4	1·97	105·5	134·4	

A trip with a much larger train of boats was made over the same course on the 22nd of August. The train consisted of eight iron barges, their bills of lading showing a cargo to the total amount of 41,300 cwt. (German), or 2,023 English tons.

The length of the course was 2·825 Austrian miles = 13·3 English miles.

The current, against which the tug moved, was as above = 2·83 English miles.

The total time of the trip was 4 hours 34 minutes.

Thus the speed of the train against the land was 0·6186 Austrian, or 2·91 English miles per hour. The speed against the current, or the speed which the train would have obtained in slack water, was 5·74 miles per hour. The total coal consumed during the trip was 35 cwt. 56 lb. (German), or 3,920 lb. (English). Thus, per hour, the coal consumed amounted to 7 cwt. 78 lb. (German), or 857 lb. (English), and proves to be,—

	lb.
Per Austrian mile and cwt. of useful load moved -	0·305
Per English mile and ton moved, - - -	0·132

Here again the same coal was used as in the previous trial (Feldkirch small coal), leaving from 45 to 50 per cent. of its weight of slag and ashes. These experiments give a few facts with regard to the power required to propel boats on rivers, the necessary coal consumed, &c., which may be of some general interest.

Considering the tug simply as a fourth vessel to be propelled by a given power, we have the following particulars about each of the four vessels, forming the train during the first experiment :—

—	Length.	Beam.	Draught.	Immersed Midsection.	Displacement, about.	Useful Load.
	ft.	ft.	ft. in.	ft.	tons.	tons.
Tug - - -	138	24½	3 9	74·39	200	—
First barge -	180	21	4 11	88·2	317	253
Second barge -	180	21	5 0	90	324	251
Third barge -	180	21	4 9	85·5	308	245

Thus we find the total immersed cross section 337·7 square feet:

	Tons.
Total displacement - - - -	1,149
„ total useful load - - -	752

The actual power transmitted to the wire rope has not been ascertained by direct experiments. Considering the class of engine, the simple gearing through which the power has to pass, and the very trifling losses by the bending of the rope and the friction of guide pulleys of very considerable size, we believe we are near the truth in assuming the actual power exerted through the rope to be 75 per cent. of the indicated horse power. The latter being 134·4 horse power, we would have in the rope itself 100·8 horse power, or 3,326,400 foot pounds. The speed of the train against the land was found to be 4·898 miles per hour, or 431 ft. per minute. The actual strain in the rope, therefore, must have been 7,485 lb., or 3⅓ tons.

The very bad coal used during the experiment will scarcely give a fair idea of the economical capabilities of the system. The residue amounted to 45 to 50 per cent. of the weight given out, in other words, nearly half of it must have been actual stones, which explains the enormous consumption of 6·85 lb. per indicated horse power. With ordinary English coal on the grate a high-pressure expansive engine with condensation would have required 3 lb. of of coal per indicated horse power at the outside. This would have given a consumption per hour of $134·4 \times 3 = 403·2$ lb. of coal, and 1,028 lb. during the whole trip.

Assuming the rectification thus suggested the results of the experiments are the following:—

Total displacement of train - - -	1,149 tons.
Useful load in three barges - - -	752 „
Total immersed midsection - - -	337·7 sq. ft.
Length of trial course - - -	13·3 miles.
Time of running - - - -	2 h. 42 m. 55 s.
Speed against land - - - -	4·898 miles.
„ of current - - - -	2·830 „
„ against current - - - -	7·728 „
Indicated horse power - - -	134·4 h. p.
Real horse power in wire rope - -	100·8 „
Strain in wire rope - - - -	7,485 lb.
Strain per ton of displacement - -	6·5 „
Strain per square foot of immersed midsection	22 „
Total coal consumed - - - -	1,028 „
Coal consumed per hour - - -	377 „
„ „ mile - - - -	77·3 „
„ „ „ and ton of displacement - - - -	0·078 „
Coal consumed per mile and ton of useful load	0·128 „

At the second trial, above mentioned, no diagrams were taken. But the facts ascertained, together with the data of the first trial, will show that very similar results were obtained under considerably different circumstances.

There were eight boats in tow, with a total cargo of 2,023 tons, each boat averaging a useful load of 253 tons. The average load in each boat at the

first trial was 251 tons. We may, therefore, safely assume that the total displacement and the total immersed mid-section of the boats will be in proportion to the average loads. Thus we find :

The displacement of the eight boats -	2,553 tons.
The total cross-section of „ -	710 sq. ft.

and, including displacement and cross-section of the tug itself :

Total displacement of the train - -	2,753 tons.
Total of immersed mid-section - -	784 sq. ft.

The speed of the tug was 2·91 miles per hour, which corresponds to 63·6 revolutions of the engine per minute.

The coal consumed per hour was 857 lb. of Feldkirch small coal. During the first trial an indicated horse power consumed 6·85 lb. of the same coal ; whilst 805 lb. per hour were burnt on the grates. In the second trial, the engine working with considerably less expansion, the coal consumed per horse-power must have been considerably greater, say 8 lb. The indicated horse-power would, therefore, be $\frac{857}{8} = 107$ horse-power, and the actual horse-power in the wire rope = 80 horse-power or 2,640,000 foot pounds. This would indicate a strain on the wire rope of 10,312 lb., a strain per ton of total displacement of 4·0 lb. and per square foot of mid-section of 13·1 lb.

In the first experiment the speed against the current was 7·728 miles ; in the second, 5·74. Supposing the theory, that the resistance increases with the square of the speed, to be absolutely correct, we would find the strains in both cases in proportion of $7{\cdot}728^2$ to $5{\cdot}74^2$. In the first case the strains per ton of displacement and per square foot of cross section were respectively 6·5 lb. and 22 lb., this would, by theoretical calculation, give respectively 3·6 lb. and 12·1 lb. for the second experiment, whilst the results above obtained were 4·0 lb. and 13·1 lb., a difference which is readily explained by the approximate value of some of the figures of the second trial and the influence which the varying currents of the river must have on theoretical laws.

Assuming again an engine, which burns 3 lb. of coal per indicated horse-power, we have for the second trial the following table of results :

Total displacement - - -	2,753 tons.
Useful load in eight barges - -	2,023 „
Total immersed mid-section - -	784 sq. ft.
Length of course - - -	13·3 miles.
Time of running - - -	4h. 34m.
Speed against land - - -	2·91 miles.
Speed of current - - -	2·83 „
Speed against current - - -	5·74 „
Indicated horse-power - - -	107 h. p.
Real horse-power, in wire rope - -	80 „
Strain in rope - - - -	10,312 lb.
„ per ton displacement - -	4·0 „
„ „ square foot of cross section -	13·1 „
Total coal consumed - - -	1,467 „
Coal consumed per mile - - -	110 „
„ „ „ and ton of displacement - - - -	0·037 „
Coal consumed per mile and ton of useful load - - - -	0·054 „

The above results would be greatly modified, when the system is applied to canal navigation proper. In this case there would generally be no current against the boats, and the speed of the train would, by ordinary circumstances, scarcely be permitted to exceed four miles an hour ; in fact, three miles an hour would be considerably in excess of the average speed at present practicable on ordinary canals.

For such a speed the train of three boats, towed during the first trial, would produce a strain in the rope of about $\frac{3^2}{7{\cdot}728^2} \times 7{,}485 = 1{,}127$ lb.

The speed being three miles per hour, or 264 feet per minute, there would be required $\frac{1,127 \cdot 264}{33,000} = 9 \cdot 016$ horse-power, corresponding to 12 indicated horse-power.

The useful load moved would be 752 tons, and as the engine in the tug could easily give off, as shown by the trials, 11 times the power thus required, it could move at the given rate 11×752 or 8,272 tons, equivalent to 41 200-ton boats. Of course it would, for practical reasons, be out of the question to employ such enormous trains. Smaller engines and tugs would be employed instead. A tug, for instance, with an engine giving off 27 to 30 indicated horse-power (equivalent to a nominal 10 horse-power engine) would tow 3×752 tons $= 2,256$ tons of useful load in, say, 11 200-ton boats at the rate of three miles an hour. The coal consumed for this smaller class of engine may be assumed to be 4 lb. per indicated horse-power per hour. Thus the whole coal consumption of the engine per hour would be $4 \times 27 = 108$ lb., or per mile 36 lb., and per mile and per ton moved $\frac{36}{2,256} = 0 \cdot 016$ lb.

This figure will, no doubt, be modified by the proportion of the cross-section of the canal and the boats which, as a rule, is much more favourable on open rivers. On the other side the tugs employed will have a comparatively smaller immersed mid-section and total displacement, and will, therefore, require less power to move itself than the larger river tug, on which the above calculations are based.

We have now to speak of the other mode of carrying out the plan of wire-rope haulage, to which we have already alluded.

The steam tug "Leitha," which forms the subject of the engravings on Plate CLXV., was built in the spring of 1871 at the works of the Danube Steam Navigation at Altofen, in Hungary, on the plan patented by Mr. Murray Jackson, and was intended, in toying heavy loads up stream, to make use of a wire rope laid for that purpose in the bed of the river. In coming down stream it was considered better to leave the cable, and make use of ordinary paddles for propelling. The "Leitha" was therefore, provided with feathering paddle wheels in addition to the hauling apparatus about to be described, and by means of disconnecting gear the one or other mode of propelling can be made available at pleasure.

The engravings on Plate CLXV. show a side elevation and plan of the "Leitha," of which the chief dimensions are as follow: Length between perpendiculars, 85 ft.; beam, 18 ft.; depth, 6 ft. 6 in.; draught with coal and water, 3 ft. 6 in. The engines are on the compound principle of 25 horse-power nominal, and are worked with steam at 60 lb. per square inch; the high pressure cylinder is 15 in. in diameter; low pressure cylinder, $22\frac{1}{2}$ in., and both have 2 ft. stroke. When hauling on the rope, the engines make 60 strokes per minute, which speed is reduced by suitable gearing, so that the driving shafts of the hauling apparatus make 20 revolutions only per minute. The usual speed when working with paddles is 45 revolutions per minute. The diameter of the friction wheels, which haul upon the rope, is 5 ft. at the bottom of the semi-circular groove. The boiler is 7 ft. diameter and 8 ft. long, with 485 square feet of heating surface, and 21 square feet of grate.

From the engraving it will be seen that in hauling upon the submerged cable, the latter is lifted free from the bed of the river as the tug advances, and before reaching the deck passes over a pulley placed for that purpose at the outer end of a radial arm, which, moving through a segment of a circle, is so constructed as to keep the rope free of the forward part of the boat, and to permit it to pass clear from side to side of the deck. This is done to facilitate the steering, for which purpose the bows are cut down, as required by the angle of the cable on leaving the water. This angle will be in proportion to the resistance offered by the load, as with a greater resistance the length of the cable raised is proportionally greater.

At the inner end of the radial arm, two vertical pulleys receive the rope between them, guiding it in a straight line to the hauling apparatus. This consists of eight grooved friction wheels of 5 ft. diameter placed in pairs ver-

tically (four above and four below), coupled together with cranks at right angles, and the two sets of four revolving in opposite directions. It will be seen from the engraving that the lower wheels are chiefly below the deck, the upper ones being wholly above it, and the point of contact of both with the cable being kept well free of the deck.

The whole of the wheels, mounted on their axles (of Bessemer steel), are placed in a strong combined frame, of hollow section, and are fitted with springs allowing a free vertical motion of the upper axles and serving to determine the adhesion required for a given load. The springs are provided with a graduated scale, the maximum load on each being fixed at half a ton. On leaving the last pair of wheels the rope is again guided between two vertical pulleys, and over an obliquely placed guide roller into the water, resuming its position on the bed of the river. It has been found necessary to form this guide roller of discs of caoutchouc to prevent cutting, and it serves to keep the cable from rubbing against the gunwale or quitting the vessel.

When it is required to use the paddles the upper wheels are raised by screw gear provided for that purpose, until the cable is quite free of the grooves, when it is thrown out sideways and the paddle wheels are connected. When the hauling apparatus is used the paddle wheels, being disconnected from the engine shaft, revolve freely with the stream.

The wire rope used for the purpose of hauling is of iron wire, and is made of six strands of seven wires in each, coiled round a central hempen core; the diameter of the rope is 36 millimetres (1·42 in.), that of the single wires 4 millimetres (0·157 in.), and the weight is about $4\frac{6}{10}$ kilogrammes per metre, or about 3·2 lb. per foot.

The speed realised through the water when towing at twenty revolutions per minute of the friction wheels is a little over $3\frac{1}{2}$ miles per hour, there being little or no slip, while on account of the moderate load upon each wheel the wear and tear of the cable has been very slight. The advantages derived from the use of a submerged cable when towing against stream, depend on the actual rate of speed, compared with the speed of the current and on the slip of the paddle wheels when such are used. If, for instance, the speed of the stream is equal to the actual rate of towing, while a tug hauling on a submerged cable makes 3 miles in an hour, one working with paddle wheels makes 6 miles in the same time, and the resistance being the same the saving would be $\frac{3}{6} = 0·5$. If, however, while towing a heavy load at the rate of 6 miles an hour with paddle wheels, the loss through slip equals one-half (and in practice it is often more at low speeds), then the expenditure of power and consequently of coal is as 1 : 0·25. Thus in working on a cable comparatively little power is required, the speed being reduced to a minimum, without those losses which attend such reduction on the usual plan.

The tug "Leitha" has towed in one convoy against stream, four barges of wood loaded in the aggregate with 1,250 tons, in addition to an iron barge with 180 tons load at about 3 miles per hour, which clearly shows how little power is required when making use of a fixed object to haul on instead of the water. A calculation of the resistance of the above load at 3 miles per hour against stream of 0·7 mile, gives 32 horse power effective (work done), without, however, reckoning resistance of the tug through the water. The consumption of coal fully confirms this, being when hauling on the cable only $2\frac{1}{2}$ cwt. per hour. In canals a great advantage to be gained by the use of a submerged cable in towing would arise from the prevention of the banks being injured by the wash of the paddles; in hauling at a minimum of speed, very little power would be required, and no disturbance caused in the water.

Lastly, in concluding this section of our report, we must mention the Austrian and Hungarian Lloyds, who, in a large [illegible] of their own, exhibited a series of models of various vessels, and also the stern post and tube, screw shaft and propeller of a vessel having engines of about 200 horse power. The propeller has four blades, with their tips bent back for the sake of getting an extra large leading radius. The system has been tried in England, but without manifesting any such advantage as to compensate for the additional risk of having the blades broken.

PRINTING MACHINERY.

In giving a description of the printing machines exhibited at Vienna it will be convenient, instead of following the geographical arrangement adopted, to take first the exhibits from the German Empire, and afterwards those from other countries. The number of the former was nearly equal to that from all the other countries put together, and the number of machines exhibited was not very far from being the same. The German section contained altogether about 25 machines, sent by 14 different exhibitors.

It may be useful to mention at the outset a few of the leading peculiarities of the Continental machines; needless repetition in the case of particular exhibits will thus be avoided. In all the single-cylinder machines, whether for book or lithographic work, the sheets are fed in *above* the cylinder (not below it, as in the Wharfedale and similar machines), and the delivery is made on a table directly underneath the laying-on table. In almost all cases the sheets are automatically delivered, the exceptions being a few of the finer lithographic presses. The commonest arrangement of the inking apparatus is very similar to that in use in this country. The colour is transferred to a slab through a ductor roller; the slab carries it to variously-arranged sets of distributing rollers, which in their turn transfer it to the type or stone. This is called in Germany the "Sisch-Färbung," or slab-inking apparatus. The slab is, however, sometimes dispensed with, and an arrangement of inking cylinders used, very much like those employed in web presses. This arrangement is called "Cylinder-Färbung," or roller-inking apparatus; it enables the machine to be made shorter for the same size of forme by the length of the slab. In some cases, where it is desired that the colour should be particularly well mixed, both apparatus are combined. Two kinds of driving motions for the platten are employed in the German machines, neither of which are used to any extent in this country. They go by the name of "Kreis Bewegung," and "Eisenbahn Bewegung," or circle motion and railway motion respectively, and the different makers seem to hold very decided, although contradictory, opinions as to their relative advantages. The circle motion is known in this country as a mechanical mode of making a point move in a straight line, but has not, we believe, been applied to printing machines. Its construction is as follows:—A pin on the underside of the platten is attached to a spur wheel (lying beneath it in a horizontal plane) in such a way that the centre of the pin is upon the pitch circle of the wheel. The wheel runs loose upon a pin which is fixed in the end of a crank having a radius equal to the pitch radius of the wheel. The teeth of the wheel, as it is compelled to revolve by the crank, which itself is driven by bevel gearing, are always in gear with those of an internally toothed rack, fixed to the framework of the machine, and having a diameter exactly twice that of the spur wheel itself. The latter thus acquires both a motion of translation round the centre of the crankshaft and a motion of revolution round its own axis, and owing to the proportionate radii and diameter being those we have stated, the absolute motion of every point in the pitch circle of the spur wheel is backwards and forwards along a diameter of the fixed rack. The driving pin of the platten is so placed, of course, as to move in the diameter of which the direction corresponds to the length of the machine. The "railway" motion is a modification of the common English "crank" motion, the principle of both being the same. In both, the platten is worked by means of a connecting rod from a crank upon the horizontal driving shaft, and in both, brackets from the underside of the platten carry, for the sake of steadiness, spur wheels which run in fixed racks. In the crank motion, however, the sides of the platten generally run upon rows of loose rollers placed on the side frames of the machine, which in this way sustain the weight and pressure. In the railway motion the platten has, in addition to the spur wheels above mentioned, four, or six, or even eight plain wheels running on rails along the machine beside the central rack or racks, and the resemblance which thus exists between the platten and a small railway truck gives to the machine its name. The driving arrangement used

in most of the French machines differs from either of these, and consists frequently of some form of rack on the underside of the platten, which is driven direct by a pinion. The cylinder machines are fitted, without exception, with grippers for holding and carrying in the sheets. Except in the machines of which in the following descriptions the contrary is mentioned, the cylinder is made always to remain stationary during the return motion of the platten, so that the layer-on has time to do his work carefully and well.

Messrs. König and Bauer (Kloster Oberzell, near Würzburg) are well known as one of the oldest and best printing machine making firms, and it may be remembered that the original heads of the firm were the men who, in 1814, made the first machine which was used in the *Times* office. They are the inventors also of the double-colour printing machine, and at Vienna they exhibited four machines, a newspaper press, a double-colour machine, a lithographic machine, and also a double press for fine work. The newspaper press has one cylinder and one forme, but has an inking apparatus at each end, and two feeding tables. It is so arranged that it throws off an impression for each motion of the forme forward or backward. It can print in this way 3,500 copies per hour on one side, the forme being 1,150 millimetres, by 700 millimetres (45·27 in. by 27·55 in.). The circle motion is used for driving the platten or table. The double-colour machine is for printing in two colours on one sheet or page of a book, and is specially arranged for printing fine work at the rate of 1,200 to 1,500 copies per hour. It has two formes, and two sets of colour-distributing apparatus, each set consisting of a complete roller apparatus combined with a circular revolving slab. The driving motion is a combination of the railway and circle motions, the upper part of the platten running on twelve small wheels. For the clean delivery of the sheets, and to avoid the use of tapes as far as possible, a wooden cylinder is provided close to the impression cylinder, the latter delivering each sheet into catches or grippers on the former, by which it is sent to the delivery table. The forme is 660 millimetres, by 420 millimetres, or 25·9 in. by 16·53 in. The lithographic press does not present any special novelty, except an adjustable apparatus for holding the paper tight. Double roller inking apparatus is used, and the ordinary railway driving motion. The fine press is intended to print 1,000 to 1,200 sheets per hour from a forme 585 millimetres, by 455 millimetres (23·03 in. by 17·91 in.) in size. It has in the centre an ordinary press with a knee motion, but in other respects is double there being two feeds, two formes, two sets of inking apparatus, &c. Each forme passes four times under the inking rollers for each impression, or to speak more correctly, the forme passes twice under the rollers, and the rollers pass twice over the forme in addition. While the rollers are moving, and the forme standing, the printed sheets are taken out, and fresh ones placed on the tympans in the usual way. The platten carrying the formes is driven by a pin working in the groove of a skeleton drum of a form not unknown in this country. According to the position of the pin, the rollers are compelled by separate apparatus to move, or the formes receive their forward or backward motion.

The Maschinenfabrik Augsburg, exhibited three machines, of which the most interesting is the web press on the Walter system, with modifications of their own.*

It is intended to deliver up to a speed of 12,000 sheets printed on both sides per hour. The sheets are 525mm. by 770mm. (20·67 in. by 30·31 in.), and the type forme 485mm. by 725mm., (19·09 in. by 28·54 in.). The action of the machine is very simple. The roll of web paper is placed at the end of the machine, as in the Walter press, but the paper is here taken from the underside of the roller instead of the top. This enables the whole printing part of the machine to be kept lower down, a [illegible] different position having to be given to the distributing apparatus for the lower cylinder. The paper first passes through damping rollers, which can be arranged to give it any required degree of wetness; and then it makes its way through rollers, which are adjustable to regulate its tension to the first type cylinder. The two type cylinders, and the two impression cylinders lie in the same vertical

* See Plate 174, Figs. 1 and 2.

plane. Their position is seen in the illustrations, the lowest and highest cylinders being the type cylinders, and the two middle ones the impression cylinders.

The paper is printed from stereotypes cast in semicircular moulds so as to fit round the type cylinders. This method is adopted in all web printing machines, and by using it the founts of type may last twenty years instead of two, while the actual printing is quite as clear and good as if it were done from the type direct. The paper first passes between the lowest pair of cylinders, and is there printed on the first side. It is carried upwards and backwards by the revolution of the lower impression cylinder, and passed from it forwards again over the upper impression cylinder, and in passing between the latter and the upper type cylinder, it is printed on the second side. As these four cylinders are all exactly of the same diameter, and are placed close together, the printing on the second side must coincide exactly in its position on the sheet of paper with that on the first. The printing operation being now completed, the paper passes horizontally forwards to the cutting cylinders. These are placed at the same level as the upper type and impression cylinders, and are necessarily of the same diameter, that diameter being such that their circumference is exactly equal to the length of the sheet which is to form one copy of the newspaper. On one of the rollers is an ingeniously arranged cutter, and on the other, at a corresponding point, a kind of groove or seat for the projecting knife. As the paper on leaving the cutting cylinder is not led upwards at a steep angle, as in the Walter press, it is not necessary to leave a small width on each side uncut, but the sheet is cut right across. The tapes, it will be seen, slope slightly upwards from the cutters in order to give sufficient height for the delivery apparatus. By an ingenious adjustment of their speed, the speed of each sheet is accelerated as it rises, so that by the time it reaches the delivery roller, there is a distance of several inches between it and the one next behind it. The delivery takes place downwards, and alternately to right and left on to the tables shown in the engravings, and the space between the sheets is necessary in order to allow time for the oscillation of the delivery frame. The apparatus for distributing the ink is very complete, that for the lower type cylinder will be seen behind and below it, and that for the upper type cylinder behind and above it. In one of the illustrations, just outside the frame which carries the cutting cylinders, will be seen an index which marks the number of copies printed as they are cut off. There are many interesting and ingenious details about the machine, but they are unfortunately of a nature which cannot well be made intelligible without the aid of detail drawings.

The Walter press, it may be remembered, derives it name from Mr. Walter, M.P., the proprietor of the *Times*, to whose enterprise it was owing that the costly experiments were made, which resulted in the production of the first successful web press. We believe the credit of its actual invention and construction is, however, due to Mr. T. C. Macdonald and Mr. Calverley, the manager and engineer respectively of the *Times* Printing Office. During the years 1863–66 the first machine was slowly elaborated, its construction being kept secret. For a year and a half more it took part in the printing of the *Times*, but still in secret, and still receiving such improvements and modifications as experience suggested, and it was not until 1868 that Mr. Walter considered the results so satisfactory that three more machines were put in hand. These were at work by the end of 1869, and since that time the *Times* has been entirely printed from web paper, with a saving in working cost so great that it is asserted on the best authority that the capital sunk in the displaced machinery was recouped in less than two years. Last year the *Scotsman* commenced printing from a Walter press, and more recently the Vienna newspaper, *Die Presse*, and other papers have also adopted it. The general catalogue of the Vienna Exhibition, as well as several of the special catalogues, were printed on the Walter press in the office of the last-named newspaper, and are noticeable as being almost the first *books* printed from continuous paper.

The second machine that was exhibited by this establishment is shown in plate 175, fig 2. It is a book printing press, and is a very good specimen of

the type of machine that appears to be most in favour in Germany.* It has a forme of 610 millimetres (24·01 in.) by 975 millimetres (38·38 in.), and is intended to be worked by hand. It requires the attendance of one layer-on, and has a self-acting delivery. It is fitted, as will be seen, with complete roller inking apparatus ("Cylinder-Färbung"), and with a single impression cylinder. The mode in which the impression cylinder is kept from moving during the return stroke of the platten, is very similar to that used in several of the machines that were exhibited at Vienna, and has been already noticed. The platten is placed in a four-wheeled truck, and is driven by the common German "Eisenbahn Bewegung," or railway motion. The various excentrics and cams necessary for the different motions of the machine are all arranged upon the crankshaft, and the countershaft so commonly used is thus quite dispensed with.

Fig. 3 on plate 174 shows the third machine exhibited by the Augsburg Maschinen Fabrik.†

In plate 170 is shown a well-designed and neatly made colour-printing press, that exhibited by Herr Ph. Swiderski, of Leipzig.‡ In general arrangement it resembles the press of Sigl's, but the bedplate is differently arranged, and many of the details also are varied. The machine is specially intended for fine work, and is therefore provided with very complete colour-distributing apparatus, which is the first requisite to securing good impressions, and the arrangement of which is clearly shown in the engraving. As lithographs containing a great many colours may often be printed on the machine, it is also provided (as in Sigl's machine) with a lever by which simultaneously the driving strap is thrown out of gear, and a brake applied, and so the machine instantaneously brought to a standstill. The lever is under the control of the feeder, who, if he sees he has placed a sheet—on which perhaps a large number of colours may have already been printed—badly on the impression cylinder, and that it will consequently be spoiled if printed, can stop the machine "dead," and readjust the sheet before the revolution of the cylinder has taken it out of his reach. The machine is also fitted with gear to enable the stone to be passed two or three times under the colour rollers for only one revolution of the cylinder, if it is desired to deepen any particular colour. The cylinder can also be thrown out of gear altogether, so as to stand quite still while the platten is moved backwards or forwards for mixing the colour, or any other purpose. The machine has the ordinary "railway" motion, the crank pin being fixed in the periphery of the spur wheel—a somewhat steadier method for such a long stroke than placing it in an ordinary crank.

In ordinary work the machine is intended to print from 11 to 15 sheets per minute, or, say, 650 to 900 per hour; the finer the work is required to be, of course the slower the speed. The largest size of stone from which this machine can print is 60 by 80 centimetres, or $23\frac{6}{8}$ in. by $31\frac{1}{2}$ in.

Messrs. Schmiers, Werner, and Stein's lithographic press, also exhibited, is very similar to the last-mentioned, but has not the brake; it has a special arrangement for guiding the paper off the impression cylinder without tapes; indeed, almost every maker appeared to have his own special arrangement for this purpose. This was nearly the only machine in which the stone can be raised by turning one hand-wheel; in all others, with one exception, two screws, and in some four (one at each corner), were required for the same purpose. The machine has also a colour knife made in more parts than usual, so that the distribution of the colour can be nicely adjusted.

Messrs. Klein, Forst, and Bohn, Johannisberg am Rhein, exhibited three well-made machines—a lithographic press, a cylinder machine for ordinary work, and a small jobbing ("Accidenz") machine. The first is strongly constructed, and adapted for heavy pressures. The stone can be set up by one screw in the centre; in other respects the machine is very similar to those already mentioned. The second machine will take in a forme 590 by 890 millimetres (23·22 by 35·33 in.), and print 1,000 to 1,100 sheets per hour. It is driven by a "circle" motion, and has a three-cylinder inking apparatus, a circular knife for cutting the sheets (when they are printed from

* See Plate 175, Fig. 3. † See Plate 174, Fig. 3. ‡ See Plate 175, Fig. 2.

two identical formes each half the full size), and, as in almost all the other machines, a self-acting delivering apparatus. The "Accidenz Presse" is very similar in general appearance, but smaller and simpler, and driven with a "railway" motion. These machines are fitted with an ingenious device for throwing the printed sheet off the cylinder, which was the subject of a patent belonging to the firm, and is now (the patent having expired) to be found also on the machines of several other makers. The cylinder has two sets of grippers, one above the paper, as usual, and one—inside the cylinder—below it. The former hold the paper, and draw it round in the usual way, and just as they release their hold, the latter move outwards and guide or lift the edge of the sheet into the tapes or other delivering apparatus.

Among the most interesting exhibits of this class in the German section was the lithographic colour-printing press, made at the Berlin establishment of the well-known Austrian engineer, Herr G. Sigl.*

This machine is intended to print from stones up to 22 in. by 30 in., and, for common work, can turn off 900 to 1,000 copies per hour. If the work is, however, to be thoroughly well done, not more than 500 copies per hour will be worked. The ink-distributing apparatus is more complete than usual, the machine being intended for fine work. The ink knife is in two pieces, adjustable by the screws seen on the back of the box. The stone itself is fixed in a frame before being placed on the platten, and thus, in adjusting it, the frame only has to be moved, without touching the stone. The stone receives the colour from four sets of rollers, which themselves receive it from the slab while the impression is being made. The impression cylinder is fitted with a double set of knives, one set gripping the paper in position in the place in which it is put by the attendant, while the other set—lying underneath—as soon as the sheet is printed, and the first set release their hold, rise up, by means of suitable gearing, and guide the edge of the sheet neatly into the delivery rollers. In order to diminish, as far as possible, the number of tapes, which always have a tendency to dirty the paper, two wooden delivery rollers are employed, and through these the printed sheet is thrown on to the delivery table by a frame in the usual way. The usual rollers and water table for damping the stone are provided at the back of the impression cylinder. The impression cylinder is driven only from one side, as will be seen in the engraving. The means by which the cylinder stands still during the return motion of the platten—making an interval in which the feeder has time to adjust carefully the next sheet in its place—is that used in most of the machines. The wheel on the end of the cylinder has its teeth planed off in one place, so that the rack can pass clear underneath them without moving the cylinder, which, however, is also (to prevent accidents) held in position when the platten commences its motion by a lever pressing against a projecting pin. Just as the platten reaches the end of its return travel, and is about to start forward again with fresh colour on the stone to print another impression, it is arranged that this lever gives the pin a slight forward motion, so as to turn the cylinder round sufficiently to bring its teeth into gear with the rack, which then drives it forward in the usual way, the lever returning to its former position to be ready to catch the cylinder again as soon as the platten arrives at the end of its travel. Spiral springs, put around the lower ends of the bolts which hold in place the axle of the impression cylinder, are used to prevent any excessive or undue pressure coming upon the stone. The stone itself, with the table on which it lies, can be raised or lowered by four screws, one near each corner, which in their turn are moved (through worms and worm wheels) by a couple of hand wheels. The platten itself, carried on a six-wheeled frame, is moved by the ordinary "railway" motion. The machine is provided with a hand lever, by which, at the same moment, the strap can be thrown off and a brake applied to stop the machine instantaneously. The object of this is that a sheet, on which, perhaps 13 colours out of 14 have been printed, may not be lost altogether if the attendant notices in time that he has placed it wrongly on the cylinder. Gear is provided by which, when desired, the stone can be made to move either two or three times under the colour rollers for

* See Plate 175, Fig. 1.

each sheet printed, and also gear by which the cylinder can be kept entirely stationary, and the platten moved backwards and forwards as many times as may be wished, in order to effect a thorough mixing of the colour.

The frame is neatly and strongly made, and the different parts of the machine are so arranged that, notwithstanding some necessary complexity, without which the various motions could not be obtained, they can all be taken apart for examination or repair with great ease.

The engine works and foundry in Berlin, best known by the name of its former proprietor, Herr C. Hummel, but now in the hands of Herr Bialon, exhibited at Vienna a large quadruple printing press—with two impression cylinders.* This machine is intended more especially for newspaper printing, and is capable of turning off from 4,800 to 6,000 copies per hour printed on one side. The size of the forme is 630 mm. by 940 mm. (24·8 in. by 37·0 in.), the most common size for German newspapers.

In the engraving *a a a a* are the four feeding tables, beside each of which an attendant stands and brings the edge of the sheets in contact with the leading cylinders *b b b b*. These cylinders are constructed in the usual way, so as only to lead in as many sheets as the motions of the forme will enable the machine to print off. The sheets are guided, in very much the usual manner, by leading tapes to the impression cylinders *d, d*, and in their revolution round these they are printed by the forme below. The arrangement is such that the sheet from the upper right-hand feeding table is led under the right-hand impression cylinder, and printed by the forme as it moves from left to right. It is then guided by the tapes under the lower feeding table, and delivered on the lower delivery table, still on the right-hand side of the machine. The sheets from the lower right-hand feeding table go directly under the impression cylinder, and are printed by the forme in its return motion from right to left. They are then guided upwards, and under the upper right-hand feeding table, and delivered on the upper delivery table. The feed and delivery on the other side of the machine are arranged in the same way. The ink-distributing apparatus is shown at *c c*, on each side of the main frame; it is of very much the usual construction. There are inking slabs before and behind the forme which transfer the ink from the rollers at *c c*, to those beside and between the impression cylinders, and from these the forme takes it. The spindles which determine the motion of the tapes are moved by spur gear so as to insure accuracy (as any unequal motion would cause the sheets to be unfairly printed), and as far as possible they are arranged to run between centres instead of in bearings. The tapes are carried over rollers (at the top of the machine), which run on pins in the ends of levers; and on the other ends of these levers are weights so as to secure a uniform tension. The platten is driven by a "circle" motion, previously described, more in use on the Continent than with us, which Herr Bialon prefers, for a high speed machine, to any of the other systems. The driving pin of the platten is fixed in the periphery of a spur wheel, which revolves freely on its centre. This centre itself is caused by an ordinary crank to revolve round a fixed point, and the teeth of the spur wheel gear into those of a fixed internally toothed wheel, the centre of which coincides with that of the crank, and which has a diameter exactly double that of the spur wheel. In this way the driving pin moves always in a straight line, the whole arrangement being, in fact, that known as White's parallel motion. The motion of the impression cylinders, &c., is given as usual by racks on the upper side of the platten.

The machine is strongly and substantially made, but far from highly finished. It is of a type which was, at one time, more highly thought of than it is now, and which is likely, as time goes on, to be more and more superseded by web printing or other perfecting presses. The machine is 5·40 metres (17 ft. 8⅓ in.) long, 2·60 metres (8 ft. 6¼ in.) broad, and 2·07 metres (6 ft. 9½ in.) high, over all.

Herr Ronniger, of Leipzig, and Messrs. Haeckel and Co., of the same city, exhibited lithographic scraper presses very much alike in construction. The machines are worked by hand, a lever being employed to give the pressure to

* See Plate 177, Fig. 2.

the scraper, to which some elasticity is given by its bearing at each end on a nest of india-rubber washers. In each machine there is a fixed cross frame above the scraper, and in this respect they differ from the Austrian machines, the arrangement of which will be afterwards described. The distribution of the metal in the framing of these machines, or the first of them, cannot be commended; if the table be not too weak the cross frame is two or three times too strong. The firm of Gebrüder Heim, of Offenbach, along with a fine collection of machines connected with the book trade, had also a lithographic press with the scraper placed in a fixed cross beam.

Herr Schierwater, of Leipzig, exhibited his new hand lithographic press, which obtained the silver medal and diploma of honour from the Hamburg Association "Zur Beförderung der Künste und nützlichen Gewerbe." The design of the machine is simple and ingenious, the damping and inking apparatus being all arranged in one frame running on small wheels, which is moved across the stone by the action of a hand lever. The pressure is given under a scraper. The impressions made by the machine are very good, but its workmanship is rough and common. One of the best points about it is the ease with which any part can be taken away, or the whole machine taken to pieces.

Several machines for the printing and numbering of railway tickets were to be found in the German section, among the most complete being those of Herr Zimmermann, of Berlin. He had both a machine for printing the tickets, with an index to show the number printed, and a numbering machine, both being self-feeding. The Gandenberger'sche Machinen Fabrik, of Darmstadt, had several machines connected with railway tickets, including one well-constructed combined printing and numbering machine, which draws the tickets out of one case and packs them again into another. Analogous to these machines were two exhibited by Herr Fritz Jänecke, of Berlin, for numbering cheques, &c. One of these prints five numbers at a time, each belonging to a different series carried consecutively on, so that five set of numbers are being simultaneously printed. A smaller machine prints one number at a time only. Two jobbing presses, by Herr Jänecke, also deserve mention for the neat modification of the "dog-knee" motion which is used in them. The rest of the German machines were of less importance, and do not seem to call for special mention.

Turning from the exhibits of printing machinery in the German, to those of other sections, it was found, as already stated, that the latter collectively scarcely outnumbered the former. America was only represented in the department of type printing by two exhibitors of presses of the smallest kind. Degener and Weiler's press is much used in America for small jobbing work; it is very ingenious, but possesses considerably more complication than the machines used for the same work in England. The forme and the tympan frame both lie horizontally while the former is being inked and the latter receiving the paper; their position is then changed by suitable apparatus to the vertical, in which they are brought into contact and the pressure applied, and they afterwards swing back again into their original places. In Galby's universal press the forme stands always vertically, the distributing apparatus is at the top, the inking rollers move up and down at the proper time over the type, and the paper, when placed on the tympan, swings upwards and is pressed against the forme.

In speaking of American printing machinery notice should be made of what appears to be a very important improvement in lithographic printing, exhibited by the inventor, Mr. C. Maurice, of New York. Mr. Maurice has boldly discarded the ordinary flat lithographic stones, and in place of them uses stone cylinders turned and drilled by suitable diamond tools. The stone cylinders thus obtained are, in small presses, mounted in bearings carried by a pair of standards, the same standards also carrying the bearings of a metal roller situated below the stone cylinder, and capable of being forced upwards towards the latter by means of a screw and hand wheel. Between the stone cylinder and the metal roller is a sheet of thick leather, which carries the paper to be printed upon.

The operation of printing is very simple. The transfer of a drawing or circular on to the stone is made by a simple rotary motion of the latter, which is also damped and inked while revolving. To take an impression, the sheet of paper is laid on the sheet of leather already mentioned, and the metal roller is then screwed up to bear hard against the underside of the leather. The stone cylinder is then simply turned and the impression taken, when the pressure of the metal roller is removed, and the leather flies back into its original position ready to receive another sheet. This description refers to the simplest form of Mr. Maurice's press, this form being, from the ease with which it is used, especially fitted for office use; but besides these more simple machines, Mr. Maurice has constructed a larger press, having a stone cylinder 28 in. long by 20 in., and using endless web paper, there being a self-acting water feeder and inking arrangement. The samples shown of the printing done by this machine were excellent, and the arrangement is one which admits of a very high speed of working, the machine being capable of turning out over 7,000 copies per hour.

Besides some examples of the smaller presses on his system, Mr. Maurice showed at Vienna one of his automatic stone-cleaning machines, this machine cleaning the stone cylinders and making them ready for receiving another transfer. This apparatus is automatic, it only being necessary to give the stone a rotary motion. Mr. Maurice is now turning his attention to newspaper printing by his system, the letterpress being in this case set up in type in the usual way, and a transfer being taken on to the stone cylinder. There are, however, several practical difficulties connected with the application of a cylindrical stone for printing newspapers on endless paper, and whether these will all be successfully overcome remains to be seen. However this may be, there are ample applications for Mr. Maurice's system, and the excellent results already obtained with it give promise of its very extended use.

In the English section the most conspicuous was the "Victory" printing and folding machine, the invention of Messrs. Duncan and Wilson, and was exhibited by the Victory Printing and Folding Machine Manufacturing Company (Limited).* Fig. 1 is a skeleton elevation of the machine, Fig. 2 being a transverse section on the line AA, Fig. 1, and Fig. 3 a similar section on the line B B. In these views A^1 and A^2 are the impression cylinders, B^1 and B^2 the type cylinders, C C the ink blocks and knives; D is the first folding and cutting cylinder, and D^1 the second folding cylinder, E being the knife for the third fold. F indicates the double rollers with tapes for the delivery of papers, G showing the papers folded and delivered on a table beneath the machine. H H are pulleys for driving the double rollers F; I I are the spur wheels and cam for working the swinging frame; J a shaft driven by a pair of bevel wheels from the driving shaft; L L are fast and loose driving pulleys; M is a cathead for turning the machine by hand; N the swinging frame; and P the roll of paper. The course of the paper from the roll to the point where it is delivered and folded on the table is indicated by arrows. The paper, it will be seen, is placed on brackets on the end of the machine, the end of the web being led over the small rollers carried on the standards, and down to the impression cylinder A^1, where it is printed on one side by being pressed against the stereotype plates on the type cylinder B^1. It then passes under and around the impression cylinder A^1 to A^2, in passing round which the reverse or blank side of the paper is brought into contact with, and printed by the stereotype plates on the type cylinder B^2. The web, thus printed on both sides, runs down between the folding cylinders D and D^1, and through the double tapes below them to the point *a*. The machine is so arranged, that at this time the middle of the sheet of paper is exactly in the line joining the centres of the cylinders, and that at that moment a transverse blunt knife, fixed in the cylinder D, forces the middle of the sheet at *b*, into the corresponding slot across D^1, in which it is caught by [illegible] grippers, and carried round in the direction of the point *c*. The half of the sheet, which had previously passed down to *a*, is of course pulled round by the grippers, as well as the half which had not previously reached the cylinders. By the time

* See Plate 176, Figs. 1 and 2.

the grippers have reached *c* with the middle of the newspaper, the end of it, that is, the space of blank paper which separates one copy from the next, has come level with the centres of the cylinders, the point *d* being now where *b* was before, and the cylinder D^1 having also taken half a turn round. At this point a knife, fixed transversely across the periphery of D at *d*, and having an edge like a very finely serrated saw, is forced through the intervening web of paper into a groove in the cylinder D^1, thereby cutting the first finished sheet or newspaper from the web. As the machine goes on, the newly-made end of the web passes down to *a*, the whole process we have described being repeated for each copy of the paper. Meantime the grippers carrying the folded sheet reach the top of the roller D, and the middle of the sheet, therefore, comes to the point *c*, between D^1 and D^2. The grippers at this instant release their hold, and a second and similar set in the cylinder D^2, at the point *f*, make the second fold in the paper, and carry it along (bringing half up from between the cylinders and half back again from the top of D^2, where the grippers had carried it) in the direction of the arrows, until it has been brought exactly under the knife E, which, by a downward motion, makes the third fold, and passes the paper through the rollers F F, to the delivery frame N. The speeds of the tapes and frame are so adjusted that the papers, as they leave the machine, are laid evenly and uniformly over each other on the delivery board.

The "Victory" machine is, we believe, the first to deliver its papers folded as well as printed, a matter of more importance in Scotland and the provinces, where newspapers are sold to the agents folded, than in London. At first sight this seems an unmixed advantage, but a little reflection will show this to be by no means the case. The great advantage claimed for the machine as above other web-printing but non-folding machines (it being conceded that web-printing machines, as such, are better for newspapers than those printing from sheets), is the saving in labour which it effects, and which is stated as follows in the prospectus of the company :—

Walter Press, to print and fold 22,000 copies an hour:
2 machines with 3 attendants each, 13 folders with 1 attendant, and 3 hands for straightening up the printed papers for the folders - - total 22

Victory Press, to print and fold 22,000 copies an hour:
3 machines with 2 attendants each - total 6

While, however, the "Victory" machine undoubtedly effects a great saving in the number of hands employed, this is by no means an accurate statement of the saving. We have often seen folding machines turning out above 3,000 copies an hour, and there is no reason why they should not go considerably higher, so that seven folders would be enough for the 22,000 copies, and these with *two* additional hands makes a total of fifteen instead of twenty-two. With the Victory Press, however, additional attendance is required to the damping machine, which is separate from the printing machine, and no account of this is taken above.

The principal disadvantages of most combined printing and folding machines are two: their diminished speed and their comparatively increased complication. In regard to the first, it may safely be said that for newspapers the first and all important point to be considered almost always is the speed with which the copies can be turned out, so that the paper may go to press at the latest possible moment. In the "Victory" press, however, although the folding apparatus reduces the rate of delivery, and makes its capacity, its capacity, according to the above statement, equals that of the "Walter" press. In reference to the other point, it is necessary to use additional care in working the machine on account of the folding apparatus, and of the tapes, any disarrangement to which may stop the printing of the paper for a time. Anything wrong in the inking or printing can also be more easily seen, and, therefore, more quickly rectified with open than with folding delivery. The separate machine for unrolling, damping, and re-rolling the paper adds considerable expense to the process, and seems the reverse of an improvement on the damping rollers placed between the paper roll and the first impression cylinder, as in the "Walter" press, and it ought also to be mentioned that the machine gives only

three folds, while the separate folding machines which we have referred to give four. Still, with all these comparative imperfections in detail, the "Victory" press possesses undoubted and great advantages.

The machine has been in process of development and improvement for some time, and will, no doubt, be still more improved in future. It shows great ingenuity in its construction, as will have been seen from our description, but we think that in the long run, for newspapers of large circulation, the open delivery "Victory" stands a better chance of coming into use than the combined printing and folding machine. The most successful working of the combined machines hitherto attained has been in the office of the *North British Daily Mail*, Glasgow, where three of them have been in constant and successful operation for about a year past, printing the daily and weekly issues of that newspaper. As with all new machines, various modifications were required after they were first set to work, but they are now giving great satisfaction. The longest run (an edition of the *Weekly Mail*), we understand, consists of from 80,000 to 90,000 copies, and is usually thrown off by the three machines in from four to five hours.

Messrs. Hughes and Kimber, of London, exhibited four machines of various kinds, the principal one being a Wharfedale press of the familiar type. This machine is for fine colour or black printing, and is of double demy size, 36 in. by 24 in. It will print 1,200 sheets per hour. The most noticeable difference between this and the Continental machines is that the sheets here are fed in from a table nearly level with the bottom of the cylinder and pass directly underneath it. After being printed the sheets are carried upwards over rollers upon a frame, and delivered at the other end of the machine. The platten has a rack upon each side, and of the two corresponding wheels on the cylinder, one is compelled always to move with it, and is flattened on one side to allow the rack to pass clear underneath it, and the other runs loose on the spindle and is always moved by the rack, but by means of a stop in the end of the cylinder is so arranged as to give it motion only in one direction, and leave it stationary while it (the wheel) moves in the other. A neat arrangement in this machine is that the crank pin is eccentric, and can be turned round through small angles, so that its stroke, and consequently the travel of the platten, can be adjusted with the greatest exactness. A small machine for the rapid printing of circulars, &c., arranged on the same principle as the Wharfedale, stood beside it. Its speed is only limited by the quickness of the layers-on, at perhaps 1,600 per hour. There is also a machine for printing cards, and worked by the foot; it has a rising platten driven by a cam. Messrs. Hughes and Kimber's fourth machine is a lithographic colour press, of the same size as the Wharfedale, and intended to print fine work at the rate of 800 sheets per hour. The sheets have to be taken off the machine by hand, the makers thinking that in this way the impressions will be more carefully made than when the delivery is automatic, and the quality of the printing, therefore, not brought so forcibly under the notice of the attendant. Instead of the customary prickers for adjusting the position of the sheet, this machine has a little brass slide on the feeding table which travels backwards and forwards through a small distance. The layer-on places the sheet roughly against this slide, which, at the proper moment—just before the cylinder grippers catch it—moves against the sheet and pushes it (without reference to whether it was accurately placed before or not), exactly into its proper position.

Belgium and Switzerland, indeed all other countries except those already mentioned, and France and Austria, were entirely unrepresented in printing machinery. The principal French exhibits came from three firms, and of these the large machines from M. Marinoni's works, at Paris, deserve the first mention. The first of these is a four-feeder perfecting machine, similar to that used by many influential European newspapers, among which are in England the *Daily News*, *Echo*, and *Globe*, and in Paris the *Figaro*, *Journal Officiel*, and *Liberté*. This machine, as its name implies, prints both sides of the sheet at one operation, and it is probably as perfect a machine as can be wished for, for printing newspapers from separate sheets of paper.

The chief features in this machine* are, 1st, the application and arrangement of six feeds or points of supply with six feed rollers, a^1, a^2, a^3, a^4, a^5, a^6; 2nd, the peculiar arrangement of the tapes and guides for conducting the sheets to be printed from the several feed rollers, a^1, a^2, a^3, a^4, a^5, a^6, to the printing cylinders b, b^1, as indicated in the drawing; 3rd, the mechanism A, for conducting the printed sheets to one or other end of the machine to receivers d, d^1, which deliver them on the tables e, e^1; 4th, the combination and arrangement of the tapes f, for conducting the printed sheets to the four mechanical receivers; 5th, the mode of inking the types by the aid of the mechanism G, G^1, either with two inking rollers j, j^1, acting alternately during each revolution of the type cylinder, or with two rollers acting continuously; 6th, the application in the machine of a movable inker i, for increasing or diminishing the supply of ink, which is regulated by a screw i^1, as desired; 7th, the application to cylinder printing machines with drawing-off gear of four receivers d; 8th, the application to the cylinder printing machines of inking and distributing rollers j, j^1, h, l, covered in leather or other suitable material. In order to print in this machine, the sheet is fed by hand from the table h^2, when it is seized by a part n^2, covered with india-rubber, which is brought in contact with the feed roller a^2 by means of a lever, m^2, actuated by the eccentric t; the sheet is then carried along by the tapes q, between the lower feed rollers a^3, a^4, which are furnished with similar tapes q^1, for conducting the sheet to the rollers a^5, a^6. The sheet held between the tapes r, s, thence passes between the cylinder g, carrying the type and the pressing cylinder b, covered with some soft material as usual, the sheet being printed on the one side by passing between the said cylinders. The rotary motion continuing, the sheet is conducted by the tapes r, v, to the pressing cylinder b^1, which, in its motion, carries round with it the sheet, and causes it to take an impression from the type cylinder g^1. The sheet thus printed on both sides is then conducted to the mechanism A, by the tapes v, x, z, whence, by the aid of an eccentric operating the rollers e, the sheet is dispatched either to the right or left of the machine by the tapes g, g^1. The sheet arriving either at point B or B^1, is conducted by the tapes f^2 or f^3, to the receivers d or d^1, for delivery on the tables e or e^1. The mechanism C, C^1, supplies ink by the aid of the roller l, from the adjustable inker i, to the inking cylinders D, D^1, on which it is evenly distributed by the rollers k, which have a longitudinal to-and-fro motion imparted by an eccentric simultaneous with their rotary motion. The inking of the types or characters is effected by the two rollers j, j^1, which are fitted so as to touch the inking and type cylinders either alternately or continuously. The progress of the sheet from either of the other tables, h^3, h^4, h^5, h^6, is the same as that described with reference to table h^2.

As we have said, the experience which has been obtained with this form of printing press, is sufficient to place beyond all doubt the advantages which the inventor claims for it. For example, from 8,000 to 10,000 perfected copies per hour are delivered from each machine belonging to the *Echo* newspaper, during their daily work, and this amount can be increased, if necessary; it follows, in consequence of both sides of each sheet receiving its impression simultaneously, that the amount of waste is reduced practically to nothing. Thus on more than one occasion, when Parliament assembled, 18,000 papers were delivered from the two presses in 65 minutes, including 25 spoiled sheets, which represented the whole amount of waste.

The flyers upon which the papers are received from the beautiful distributing arrangement are of course no novelty, being of the ordinary form which, originally designed in America, has been in use here for many years. The precision of their action is, however, worthy of notice. A comparison of the leading features of the Hoe and Marinoni presses contrasts strongly the difference between the two systems. A ten-feeder Hoe press, capable of printing 18,000 sheets per hour on one side only, requires 14 hands to attend to the laying on, taking off, and the general management of the machine; it absorbs 20-horse power to drive it, and weighing from 20 to 25 tons, occupies a space 25 ft. by 7 ft., and is 25 ft. high. A Marinoni six-feeding machine, on the

* See Plate 197, Fig. 1.

other hand, capable of turning out 9,000 perfected copies, requires only seven men to tend it, and 3-horse power to drive it; the weight is 10 tons, and its outside dimensions 22 ft. long by 7 ft. wide, by 10 ft. high.

Marinoni's web printing machine, which formed the subject of a patent about two years since, is however, a more interesting machine; it may not be too much to say that it was the most interesting exhibit of its class in the Exhibition. It is said to be able to print on both sides, 20,000 copies per hour of a newspaper the same size as the *Times*; but unfortunately, it was not at work, owing to the enormous expense of supplying paper to a machine running at such a speed. The mechanical difficulties of web printing having been successfully overcome, there was no difficulty in printing as fast as the cylinders could be driven, except that of getting the papers properly delivered; 6,000 or 7,000 copies an hour is about the maximum number which can be conveniently delivered on to one table, and the Walter press, with its 12,000 copies per hour, divides its delivery into two, sending the sheets alternately to right and left of the delivery frame. The special feature of the Marinoni press is that it divides its delivery into four, so that it delivers one quarter of its total on to each of four tables arranged in pairs, one above the other, at the ends of the machine. The apparatus for directing the sheets as they come from the second type cylinder to each of the four tables in turn, is of the most ingenious kind, and at the same time quite simple in its construction. In a well-organised newspaper office the operation of taking away the spindle of a finished roll, and putting a fresh roll in its place, resembles very much the working of a gun by trained artillerymen—every man stands in his proper place, and the whole operation is performed as if by machinery, and in the minimum of time. The delay from this cause would, however, be much more serious in the Marinoni than in the Walter press, because, owing to the greater speed of the roll, it would occur nearly twice as often, and also because the roll has to be lifted to a considerable height (small jib cranes are fitted for the purpose to the frame of the machine) instead of being just clipped into journals close to the ground. This difficulty is got over by having places for two webs in the machine, one on each side, and printing alternately from the right and left web, the other being meantime put in place. No stoppage is necessary therefore, except the few moments required to enter the end of the new web. As to the rest of the machine, we may mention that the paper is damped as in the Walter, that the sheets are cut *before* being printed, and that the type and impression cylinders are arranged horizontally beside each other, instead of vertically. The workmanship of the machine is very beautiful, but the framing certainly seems very light in some places, especially in the brackets for supporting the paper rolls. The Exhibition Supplement of the *Neue Freie Presse* was printed in the pavilion of that newspaper in the grounds of the Exhibition upon a Marinoni press, made by Sigl, of Vienna. This machine was, however, fitted with folding apparatus, and attained great speed.

Fig. 3 of plate 176 shows the arrangement of this machine,* in which R R^1 are two rolls of paper, each 5,000 yards long. The paper from one of the rolls (the second being kept in reserve) passes over a small drum *a*, where it is wetted; *b* is a trough containing water, which is carried by the cylinder *c*, to the wetting cylinder *a*. From the wetting cylinder the paper passes over the wooden drum A, whence it is carried by tapes down to the cylinders B B. These two cylinders are provided with knives N N, which cut the web into sheets of the size required for the newspaper. Each sheet so cut is then conducted by tapes between another pair of wooden drums C C^1, where it mets the margin tapes, which take it round the two blanket cylinders, D D^1, where it receives the impression on each side from the cylindrical stereo-plates mounted on the cylinders F F^1. The two inkwells are shown at H H^1, from which the ink is taken and distributed on the cylindrical tables G G^1. The vibrators and the distributing rollers for the ink are shown at *r*, r^1, r^2, r^3, and r^4, r^5, are the inking rollers.

That portion of the machine in which the greatest ingenuity has been shown should next be explained. Comparatively little difficulty has existed in

* See Plate 175, Fig. 4, and Plate 176, Fig. 3.

making a machine to print at a high speed, but trouble has always been experienced in clearing the printed sheets from the machine.

Sheets following each other continuously may, of course, be printed as fast as the cylinders can be driven; but to take then off is the difficulty. It must be remembered that the paper is guided by tapes. Immediately the printing is over, the sheets are sent in four different directions by the aid of a "divider," which forms a special feature of the Marinoni press.

The tapes that guide the sheet whilst it is being printed may be called set No. 1. These carry the sheets round the cylinders, and then passing round small iron rollers in different directions release it from their hold. It would be impossible, however, for the sheets to be delivered indiscriminately from the machine. Exactly opposite, and almost in contact with the small iron rollers, are a set of similar rollers, and tapes that may be called set No. 2; by the side of these is another set, No. 3. A reciprocal motion is imparted to No. 2 and No. 3. No. 2 comes opposite No. 1 exactly as one sheet is about to be delivered, and thus the sheet runs into No. 2 set; by the time the following sheet is ready, No. 3 set has moved opposite No. 1, and therefore the sheet runs into that set of tapes; and as No. 2 and 3 run on opposite sides of the machine, the sheets are thus separated. Thus, as only every other sheet goes into No. 2 set, the distance between the sheets is increased from 1 in. to the full width of the sheet, on each side of the machinery. Even this is not sufficient to insure the correct delivery of the sheet, and a secondary system, similar to the one just described, is repeated after the sheets are in Nos. 2 and 3 sets, by which they are again separated, one sheet being carried to the top and another to the bottom of the machine. Thus the sheets, though within an inch of each other, at the instant of printing, are separated by three times the width of the sheet before they are delivered. When, therefore, they are thus separated by being conducted in four different directions, it is easy for them to be delivered.

This is the most important feature of the machine, and it gives it a great advantage over all the other web presses now in existence, as these have hitherto failed in their arrangements for delivery, the Bullock American press having only one delivery, whilst the Walter press, although having two, requires two hands to receive the sheets as they are delivered.

M. Alauzet, of Paris, sent a larger number of printing machines—9 or 10 in all—than any other single firm. The largest of these is a four-cylinder newspaper perfecting machine, to turn out 6,500 finished copies per hour of a full-sized Paris newspaper. It requires, of course, eight attendants, there being four feeding and four delivery tables. Beside it is a two-cylinder press, with double feed and delivery, which, with four attendants, will turn out 4,300 copies per hour, printed on one side. Both these machines are fitted with Normand's patent elliptic pinion, which enables the delivery to be greater, and the speed more regular than it would otherwise be. For book-printing, the most important machine is a perfecting press with double feed and single delivery, intended to finish illustrated or fine work at the rate of 1,200 to 1,300 copies per hour. It is similar to that used in Paris for the *L'Illustration* and other illustrated papers, and is made to work either by hand or power. There are also two smaller machines for general book-work of the better description, both of which are what M. Alauzet calls "direct-acting," that is to say, by rack or otherwise, without the intervention of a carriage or spur "circle" gearing. The smaller of these machines is known as the "Express" press. For lithographic printing, M. Alauzet exhibits only one machine, a very complete and well-finished one, including a number of patented improvements in its details. The chromo-lithographs printed by this machine are of the highest excellence. It is driven by a "railway" motion, and in general appearance is very similar to the German machines. The improvements referred to have chiefly for their object to increase the finish of the work. The printed sheets have to be taken out by hand, for the reasons already stated. M. Alauzet exhibited also a Stanhope press, a machine for mixing colours for lithographic work, &c. The workmanship of these machines is very good, and the designs of the frameworks, without any attempt at ornamentation, show great taste.

Messrs. Maulde, Geibel, and Wibart, of Paris, whose combined engine has been already noticed, showed four printing machines, the making of engines being with them only a secondary business. The first of these is a book press, with railway motion, and having a large wooden delivery cylinder, which renders it possible to dispense entirely with tapes. A smaller book press is very similar in design to Alauzet's "Express" machine. A little press, on Groselier's patent, worked by the foot, is very neat. It has the common tympan frame for the sheets; the forme does not move, but is inked by the rollers passing over it. The platten is pulled down upon the forme by a couple of cranks. The last machine that was exhibited by this firm is a lithographic press. It has only roller-inking apparatus, and is consequently shorter by the length of the slab than the usual machines for the same size of stone. Its special peculiarity is that the stone, instead of being rigid, rests on a frame which is supported by a pin running in the direction of the length of the machine. It is so far free to oscillate on this pin that either side of the stone can move one centimetre up or down. It is thought that in this way a more even pressure can be obtained, the stone being to a certain extent self-adjusting to the surface of the cylinder. The apparatus for making the cylinder remain stationary while the stone passes twice or more under the inking rollers, is brought, by means of a hand lever, much more conveniently under the control of the attendant than it is in most of the machines.

With the exception of the three firms now mentioned, there were no French exhibitors of any importance in the present section. There were only some small lithographic hand presses by Alexander Lagrange; a neat card printing machine by Pierron and Fd. Dehaitre, and a Degener and Weiler, by the same maker.

If the Austrian printing machine makers were fairly represented at Vienna, it would seem that the trade is carried on only to a very small extent in that empire, few of the machines exhibited being of any size or importance. The Sigl-Marinoni press in the pavilion of the *Neue Freie Presse* has already been noticed. In addition to this there was also a lithographic machine of Herr Sigl's exhibited, but not by the maker himself. This machine has several peculiarities; the cylinder itself is combined with a scraper; the arrangement for allowing the stone to move two or more times for one revolution of the cylinder, is (as in Maulde, Geibel, and Wibart's machine just mentioned,) commanded by a hand lever placed conveniently for the attendant; two scales of centimetres at right angles to each other are placed on the platten, and by these the position of each stone is noted, so that it can be placed again in the machine with the greatest accuracy in the exact spot where it was before. The machine is both simple and strong, and is intended to print 800 impressions per hour from a stone of a maximum size of 30 in. by 20 in. Herr Sigl holds a patent for his combination of the cylinder and scraper. Herr Kaiser and Herr Anger, both of Vienna, exhibited small cylinder presses for bookwork, which do not call for special comment, and Herr Rust has a common lever jobbing press.*

Herr A. Fichtner, of Vienna, had a collection of four or five lithographic scraper presses. They are well made, but it seems somewhat to be wondered at that such slow-working machines should command any sale when the cylinder machines can so easily be had. The scraper machines are, however, of course much cheaper. The maker has a patent for the arrangement of the scraper, which instead of being thrown upwards when out of use, is thrown to one side. As the lever and scraper form together a very considerable weight, this arrangement saves a good deal of trouble. Herr I. J. Bachrach, of Vienna, showed several small hand or foot presses for visiting cards, circulars, and such small work. They are very simple in construction, and mostly print at the rate of about 1,000 copies per hour. In the smaller machines, the printed card or paper is thrown off to the side by a jerk of the frame; in the larger ones, both the laying on and taking off has to be done by hand. Herr Ludwig Schember exhibits his patent "autographic multiplication press," for printing circulars, &c. It is a very useful machine, and by its small price

* See Plate 177, Fig. 3.

commends itself to many, who, although not printers, have occasion frequently to send out large numbers of duplicate circulars of any kind. The manuscript to be printed is first written with prepared ink upon well-sized paper, and then transferred to a metal plate, from which it is printed. From 80 to 100 copies can be made in an hour, and the machine appears simple enough to be worked by a boy without any special training.

The only other machine that calls for special mention is Putze's patent card-printing press, which was exhibited by Messrs. Putze and Habernal, of Vienna. This is a very ingenious little machine—bearing some resemblance to a railway ticket printing machine—for printing address cards. It is 12 in. long, 7 in. broad, and 8 in. high, and weighs 30 lb., and it will print cards from 2½ to 4 in. long, and of proportionate width. Its general construction cannot well be made intelligible without the aid of illustrations; it must suffice to say here that a packet of about a hundred cards is placed at one time in a case at one side of the machine, and that at every stroke, the bottom card of the pack is pushed away and carried under the little platten, where it is printed, and then dropped into a box. As each card is taken from under the pack, the others are pressed down to occupy its place, and the machine does not seem to have any difficulty in finishing the hundred cards in a minute.

All the printing machines of any importance which were to be found in the Exhibition. It may be added, that in this sub-section of Group XIII., as well as in some others, several machines appeared in the Official Catalogue which a dilligent search failed to discover in the Machinery Hall, and which it is to be therefore concluded were never sent.

MACHINE TOOLS.

Machine tools of all kinds formed a very important section of the exhibits collected in the Machinery Hall at Vienna, and there is probably no class in which the examples shown were so numerous. The number of instances in which real originality of design was shown was, however, far from being great, and where it did exist it far more generally showed itself in the improvement of constructive details rather than in the introduction of machines of entirely new types.

United States.

For the number of machines it included there was in fact no collection of tools in the Machinery Hall which could compete for real originality of construction with that to be found in the American department. Setting aside the wood-working machinery, which is treated in a separate section, we found in this department three chief exhibitors, namely, Messrs. W. Sellers & Co., of Philadelphia, Messrs. Pratt and Whitney, of Hartford, and the Brown and Sharpe Manufacturing Company, of Providence, all of whose exhibits well repaid careful examination.

Messrs. W. Sellers & Co., of Philadelphia, are well known as the Whitworths of America, and their exhibits at Vienna well sustained their reputation both by their design and excellence of workmanship. The most prominent exhibit at Messrs. Sellers' stand was a revolving puddling furnace constructed on Messrs. Sellers' plans, and intended as a rival to the Danks furnace. This furnace is undoubtedly a machine tool according to the strict sense of the term, but it belongs to a class of exhibits connected with the manufacture of iron and steel, with which we have dealt separately, and we shall therefore not enter into particulars of it, but shall merely remark that it includes some very convenient points of arrangement which render the invention well worthy of attention. Two other exhibits of Messrs. Sellers,

namely, a small steam hammer and a rolling mill, may be spoken of first as being associated with the furnace just mentioned. The rolling mill was especially worthy of notice, as being really a machine tool, and not merely a rude contrivance for rolling iron, such as is too often to be met with in iron-works. It was of an excellent design throughout, and included several specialities of detail worthy of attention. The steam hammer just referred to was of the "Morrison" type, and was double acting. Although of the Morrison pattern, however, it was characterised by several peculiarities and improvements, introduced by Messrs. Sellers. Amongst these we may mention that the hammer bar is of greater diameter below than above the piston, and that the hammer head is loose, and is attached to the hammer bar simply by the insertion of a circular key or tapered ring in the space between the bar and the socket formed on the upper side of the hammer head. This circular key is cut through on one side, and each blow of the hammer tends to drive it more firmly home. The hammer head fixed in this way can be at once released by withdrawing the die and allowing the hammer bar to strike upon something, less than its own diameter in width, placed on the anvil. This being done the head simply falls off the key. This mode of fixing gives the greatest possible facility for adjusting the head, so that the dovetail for the die stands at any required angle. The die is held by a crimped key, which Messrs. Sellers recommend as superior in many respects to an ordinary key, and the top of the die is borne upon by the hammer bar direct. Several improvements have also been introduced in the details of the valve gear of these hammers, and provision is made for throttling the exhaust below the piston, when it is desired to strike a light blow.

Amongst the regular machine tools was a small planing machine of Messrs. Sellers' well-known type, with framing of good rigid design, and with the table driven by a worm gearing into a straight toothed rack fixed to its under side. The teeth of this rack stand at right angles to its centre line, and the worm which gears into it has its axis inclined to the axis of the machine at such an angle that the upper part of the screw thread which is in gear moves parallel to the teeth of the rack. When this mode of driving planing machine tables was introduced by Messrs. Sellers some 16 years ago, it was a matter for surprise that the worm did not show signs of rapid wear. Experiments made with a large-sized model, however, showed that owing to the relative positions of the worm spindle and the axis of the rack the combined rotary onward motion of the latter, combined with the rotary motion of the worm, produced what was approximately a rolling contact between the worm and teeth surfaces, the amount of sliding movement being very small. As a fact, this combined rack and worm movement is run on Messrs. Sellers' machines without any lubrication beyond that which may leak on to the worm from the adjoining bearings of the worm spindle, and so far one of these worms has never required renewal. In the revolving furnace, to which we have already briefly alluded, a similar mechanical movement is used for another purpose. In the planing machine, of which we have been speaking, the worm spindle is by means of bevel gear connected to a shaft placed parallel to the axis of the machine, this shaft carrying the belt pulleys. It follows from this arrangement of the belt pulleys that instead of the machine standing at right angles to the line of shop shafting, as is usually the case with planing machines, it stands parallel with that shafting, and in the same line as the lathes and other machine tools. This appears to us to be a decided advantage, and we wonder that the arrangement has not been adopted in this country.

The machine under notice is also fitted with a very neat arrangement of belt gear, this being so contrived that, in reversing the machine, the open belt is shifted from the fast pulley on to its proper loose pulley before the crossed belt is moved at all, and vice versâ, the belt first shifted thus remaining stationary while the other belt is being changed on to the fast pulley. The effect of this arrangement is to reduce the lateral traverse of the belts one half, and thus not only to allow of the employment of narrower pulleys, but also to reduce the wear and tear of the belts. The belt pulleys, we may add, are situated on the side of the machine where the man stands. Another neat point

in this machine is the arrangement for lifting the tool during the return traverse the lifting motion being transferred to the tool-holder by a light cotton cord, which acts at whatever angle the tool-holder may be set. One feature of all Messrs. Sellers' machines we may also mention here, as it is especially noticeable in the machine of which we are now speaking, and that is the mode of finishing the flat surfaces. Surfaces which require it are of course finished by scraping in the usual way, but other flat surfaces, as, for instance, the top of the table of the machine under notice, are left just as they come from the planing machine, and the marks on them show that the finishing cut has been taken with a $\frac{5}{8}$ in. feed. This exceedingly broad feed for the finishing cut gives Messrs. Sellers' tools, when new, a characteristic appearance, which is different to that of any other maker with which we are acquainted. The finish is excellent.

Another good tool at Messrs. Sellers' stand was an engine lathe, which in the catalogue was called a 30-in. lathe, and which we illustrate on Plate CLXXXVI. and Figs. 4 to 11, Plate CLXXXVII. The actual height of its centres above the face of the shear or bed was $14\frac{3}{8}$ in., but the longitudinal central opening in the bed being $10\frac{7}{8}$ in. wide, permits work 30 inches in diameter being finished, at the face plate or anywhere except over the slide rest, the radius of $15\frac{1}{2}$ in. from centre clearing the bed. It is common practice in America to rate lathes by the greatest diameter they will swing clear of the bed (or, as they name it, the "shear") and not by the height of the centres. We mention this as explaining a difference in nomenclature that might mislead those of our readers who are used to hearing lathes called by their height of centres.

From a paper on self-acting slide lathes placed in our hands by the makers of the tool under consideration, we gather some of the reasons that actuated them in deviating from the established forms of lathes in most common use. They say, "the turning lathe, being the oldest of all machine tools, has been "more hampered by traditional devices and shapes than more recently con- "trived machines. Changes for the better have to be made often in opposi- "tion to prejudices of the working men." This is particularly so in their case, as among other changes from the practice in their country, they have adopted what is known as the "flat top shear," familiar enough to our workmen, yet but little used in the States, the majority of American lathe makers adhering to a bed with V guides on the upper surface.

In adopting the flat top, however, Messrs. Sellers introduce a novelty in the mode of guiding and clamping the back head. Convenience in moving requires that this head which is guided by the inner edges of the bed top, should slide easily, and hence should fit loosely. It is of the utmost importance that it shall always hold the same position as to line with the other parts of the lathe when clamped. This suggested to these makers the placing of a V guide on the under side of one of the inner edges, and this by means of the clamping shoe, always draws the head up to the same straight edge. This is shown in section in Fig. 6, Plate CLXXXVII., where the back head is represented in its position on the bed. When the clamping bolts which draw this shoe up to its place are loosened, the head is quite free to move. When they are tightened the head is pressed firmly against the edge carrying this V under it, which edge being subjected to no rubbing wear maintains its alignment with the centres. The two sides of the bed are connected at intervals of about 2 ft. by cross stays of an I section extending from the base of the bed to as near the top surface as is possible, and yet leave room for the clamping shoe of the back head and the nut of the slide rest to work with the lead screw. This nut does not clasp the screw; and the lead screw itself, in its position in the bed, is worthy of especial notice. It rests in a trough extending the whole length of the bed, only about one-third of the circumference of the screw being exposed to the nut. The nut is a wide plate of cast iron, guided by projections downward from the saddle of the slide rest, and makes up in length for the loss of surface in not clasping the screw (see Fig. 7, Plate CLXXXVI.) The screw is held from end motion by substantial collars at one end only. Being supported its entire length it is subjected to no vibrations, nor can it alter its length by swagging down between its supports. It lies entirely under the

overhanging edge of the shear out of the way of falling dirt or ships, and is thus protected from injury. The lead screw in this lathe is used for screw cutting only, ordinary turning being done by a separate feed, actuated, primarily, by friction discs from the live head spindle, as we shall explain hereafter.

The slide rest is compound, and is shown in Figs. 7 and 8, Plate CLXXXVI., and Figs. 7 and 8, Plate CLXXXVII. The top slide carrying the tool post is operated by hand only. It can be set at any angle to the axis of the lathe, as the post upon which it rests is guided by an annular tongue projecting into a circular slot in the cross slide of the lathe. This post is graduated at its base, and can be clamped by holding-down bolts in any required position. A long cross slide rests on the saddle, and its screw can be worked by hand, or its nut rotated by power, so as to accomplish an automatic cross feed for facing work. This cross slide entirely covers its guides, or slide on the saddle, so as to exclude all dirt from the rubbing surfaces. The saddle itself is guided by the outer edges of the bed, and lost motion is taken up by a gib at the back of the lathe bed. For turning only, a rack feed is made use of, the rack being under the front edge of the bed top. A feed rod driven by the friction discs before alluded to, lays along the lower edge of the bed, in front, and the train of gear wheels, taking the power from this to the pinions and rack, are carried by an apron, depending from the saddle. A right-hand and left-hand worm on the feed-rod gearing either one into the same worm wheel, as is common in other makes of lathes, actuates the feed; the stopping and starting being accomplished by means of friction clutches, one in the worm wheel, for the longitudinal feed, and one in a large spur wheel, gearing into the nut wheel of the cross slide, for the cross feed. These two feeds are either one operated by the same hand-wheel in front of the apron. The determination of the feed required is effected by a screw in the boss of this hand-wheel; this screw has handles convenient for operating it, and the turning of it as far as it will go in one direction renders the use of one feed possible, and the turning of it, as far as it will go, in the opposite direction, renders the other feed possible; after which the same motions of the hand-wheel stop and start which ever feed may be in adjustment. In reference to this feature we quote from Messrs. Sellers' paper, "Such motions as screwing up the spindle of the poppet head (back "head), stopping and starting feeds, setting up the slide rests, &c., are "motions of habit, and should if possible be uniform on all lathes. This is "especially the case where two kinds of feed are operated by the same "starting gear. No complication of motions should embarrass the workman. "There should be no hesitation on the part of the workman as to which "way he should move the starting gear in any case." In the live head of this lathe there are several noticeable deviations from traditional form and devices. The lathe on exhibition was what is called triple geared, *i.e.*, besides being provided with the usual back gear, the pinion on the back shaft gearing into the largest wheel on the spindle for the slow motion is made to slide to one side out of gear, and a small pinion can then be placed on an overhanging end of the back shaft in gear with teeth on the face plate. It is noticeable that there seems less reduction of speed in the back gear than is common; but we are informed that this is to admit of a perfect graduation of the rates of speed. Thus the cone pulley is provided with five lifts or speeds. This gives five speeds without any gearing, then five speeds are obtainable by means of the back gearing, in combination with the cone speeds, and five other speeds with the triple or face plate gear, making 15 speeds in all, form a uniform rate of countershaft. These speeds have been so regulated or graded in the proportion of the gearing that the rate of increase or decrease of speed is the same throughout the series. The cone pulley is turned inside and out, so as to be perfectly balanced. The front journal of the spindle is cylindrical, the back one conical, as shown in Fig. 1, Plate CLXXXVI.

The bearings of bronze are both cylindrical on their outer surfaces. The most striking feature of the spindle is the device for preventing end motion and resisting the back thrust. Back of the back bearing is a cylindrical

cast-iron box, bolted to the lathe head by four screws. A prolongation of the spindle extends through this. A hardened cast-steel collar is keyed to the spindle and held in place by a thin sleeve extending through the back of the box, and holding the collar up to a shoulder on the spindle; great care being taken to make this collar true. A second hardened collar forms the bottom of this box, and it is between this latter hard surfaces and the end of the back bearing that the collar on the spindle revolves. The thrust in work comes on the hard surfaces, under an efficient system of lubrication. Thus this fixed collar at the back end of the spindle is made to do the duty of the conventional collars at front end of the spindle and of the usual tail screw at the back end of the spindle. Provision is made by recessed brass rings in the hard collar for possible adjustment of the parts, the idea being to render such adjustment possible under proper supervision of foreman, but not within every day reach of the workman operating the tool. On the back end of the spindle where it projects through the box is a gear wheel, driving one of half its size on a stud below it. This last wheel performs the double duty of actu ating the first wheel of the change gear in screw cutting, and the first or driving discs of the friction feed for turning only.

These friction discs can be readily understood from Figs. 1 and 5, Plate CLXXXVI. They consist of two circular plate wheels on the same plane, each having a slightly raised rim, the one acting as driver, the other being placed on the shaft to be driven; motion is conveyed from one to the other by two clamping discs, convex on their clamping surfaces, and pressed together by spiral springs acting on ball joints on the bosses. The position of the clamping discs in relation to the two plate wheels, determines the velocity of the driven wheel. The clamping discs are carried in a forked lever and are moved into position by a screw. This feed is said to have proved efficient in practice, and to be in use on all tools of Messrs. Sellers' make to which it is applicable. It permits any gradation of feed to suit the nature of the work between the extremes of speed.

The form of the live head stock is such as to secure stability. The back shaft is thrown out of and into gear by eccentric bearings operated by levers and a uniting cross-bar, as shown by Figs. 3 and 5, Plate CLXXXVI.

We learn from Messrs. Sellers that the practice of fixed face plate and triple gear, also of bronze bearings for the spindle, holds only on lathes of 25 in. swing and over. Smaller sizes, say 20 in. swing and under, are made with loose face plates, *i.e.*, with face plates screwed on to the spindle, and the spindles are made of hardened steel, running in hardened steel bearings, all ground accurately true after hardening. The conical holes in the spindles to which the loose centres are fitted, are made true after all other parts of the spindles have been adjusted, so as to insure absolute correctness to the point of the centre when in place, and to permit the lathe centres to be ground sharp in a separate machine in the tool room, and yet run true in place in the lathe. We have already mentioned Messrs. Sellers' method of holding down the back head of the lathe, so as to insure its alignment by means of the V on the under side of the flat top shear. The spindle of this head is clamped at the projecting nose of the head next to the work by means of a split conical sleeve, forced in by a screw cap over the end of the spindle bearing. This takes up all lost motion or play, and insures its central position.

The back head is provided with a means of adjustment sideways for turning tapers, but we imagine this must have been adopted under protest, for in Messrs. Sellers' paper they say, "If lathes were not required to turn tapers as "well as cylinders, there can be no doubt that the poppet head made in one "piece, resting on the shears over a sufficiently broad surface and capable of "adjustment sideways only to the extent of practical alignment, would be the "simplest and the best. In our practice we prefer this system, and adapt to "lathes requiring it a device which enables the turning tool to be guided by "former bars, and thus to produce tapers or irregular shapes, such as the "curves of handles, &c. This device, called technically 'a former attach-"'ment,' does much better conical or tapered work than with centre set

" over out of line, for reasons obvious to all familiar with the use of the " machine, and gives a greater range to its capacity." To this may be added that the use of formers actuating and controlling the motion of the tool in the slide rest enables work which is chucked to the face plate to be either turned or bored to taper or to any required shape as readily as when held between centres.

Another good machine at Messrs. Sellers' stand, was the slotting machine, illustrated by the various views on Plate CLXXXVIII.

This machine is termed in the catalogue of the makers a 48 in. slotting machine, *i.e.*, it has sufficient over-reach to enable it to slot the eye of a wheel 48 in. in diameter. As shown in Plate CLXXXVIII., the slotting tool is operated by means of a crank driven by what is known as the " Whit- " worth motion," giving a slow movement under-cut and a quick return. The crank is adjustable in length of stroke, the maximum being 12 in. The adjustment for length of stroke is by a screw in the crank plate, the adjustment of connexion of the connecting rod, with the slotting bar is also by means of a screw, so as to regulate the position of the slotting bar in height from the table upon which the work rests. The attachment of the connecting rod to the slotting bar is by means of a wrought-iron block always in connexion with a counterbalance lever. The counterbalance is in excess of the weight of the slotting bar and any ordinary cutting tool, so as to take up all lost motion, and steady the operation of the machine under cut. The bearing or slide carrying the slotting bar is adjustable to suit the different heights of work, and enables the bar to be guided as near the work as possible. In fact when the nature of the work will permit, the supporting bearing can be carried quite close to the table, thus giving a firm backing to the tool during its whole stroke, and insuring steadiness of motion. It is noticeable that the connexion of the connecting rod to the slotting bar is off to one side of the centre of the crank on the pulling down or working side of the crank. This places the crank and connecting rod in the best relation for work with the least side strain on the vertical slide under cut, while on the up-stroke its consequent increased obliquity to the line of motion does no harm. The compound table upon which the work is bolted consists of the usual compound slide rests of broad surface with a rotating table on top of the upper cross slide, all provided with automatic feeds. These feeds are obtained from one primary motion, a ratchet feed wheel operated by a cam at the back of the large driving wheel. This cam is so constructed as to insure the occurrence of the feed at the top of stroke, while the crank is passing its dead centre.

The conveyance of this feed to any required part of the machine is effected by means of one gear wheel with a square hole in its eye, to fit on the squared ends of the various feed screws and shafts. Thus for the longitudinal feed this wheel placed on the end of the feed screw at the back of the bed, where it is shown in position in Figs. 1 and 2, gears into a wheel between the ratchet wheel and this screw, while the cam feed and circular feed are driven from a wheel travelling with the compound table, and driven from the ratchet wheel by bevels, and having its pitch line the same distance from both of the two shafts, so as to be within reach of either with the same wheel. The longitudinal feed by hand is obtained by bevel wheels within the bed and a square end for a crank within reach of the workman when he is handling the other feeds. This is claimed by the makers as a very important feature of their machine, and they say in a publication on this subject. " There is scarcely " any machine tool requiring more close watching on the part of the work- " man on the class of work it is required to do; it seldom takes long cuts, it " generally being but a little while under power feed at a time, and the " amount of production, all other things being equal, depends upon the readi- " ness with which the attendant workman can do his part of the movement " in adjusting and readjusting the work in various positions, and keeping " the tool under cut as much of the time as possible." This can be illustrated in one class of work in common practice, viz., the key-seats of wheels. Care is required to adjust the wheel in place, so as to have the sides of the key-seat parallel with a diameter line. This requires some little time, while but few strokes of the slotting tool are required to cut the key-seat after it is made

ready. It is thus evident that convenience of adjustment in such work will greatly influence the amount done.

We must now speak of the gear-cutting and wheel-dividing machine exhibited by Messrs. Sellers, this machine including some exceedingly neat points of design. The machine, which is illustrated by various views on Plate CLXXXIX., is arranged for cutting both spur and bevel wheels, and has a capacity up to 54 in. diameter of wheel, 12 in. face, and will cut a number of small spur wheels of the same size at one time. The peculiarity of this machine is in its being entirely automatic. It performs all its work, after adjustment, without attention of a workman, to the completion of the wheel being cut or divided. The division is obtained by a tangent wheel and worm in connexion with a system of change wheels between the worm and the crank handle, so that the turning of the crank one, two, or three times, as may be called for in connexion with specified change wheels in the schedule of division, gives the number of teeth required.

So far the machine is similar to many gear cutters in common use, but in this machine the turning of the handle the proper number of times at proper intervals, as well as all other motions required, are automatic. Thus a blank wheel being put in place, and the cutter adjusted to depth of cut, length of stroke of cutter head, &c., the cutter passes across the face of the wheel, cutting the space between two teeth, then returns at a quick pace to the starting side of the wheel; the blank is then turned to present a second space to be cut, and the cutter restarts its proper motion in another space, to the completion of the wheel, all without attention from the workman. While in method of dividing, speed, and power of cut, it may not differ from other well-made gear cutters, yet, inasmuch as it loses no time between its cuts, but performs all the motions required promptly and as rapidly as possible, it is claimed by its makers to do one and a half times the work that a skilful workman can produce on a gear-cutter operated partially by hand. In practice it has been found that one man can attend advantageously four of these machines, each machine doing more work than one hand machine, yet really using but one fourth of the workman's time. An important feature in this machine is, that the various movements required to do the work follow each other in regular sequence, each one being dependent on the completion of the motion which preceded it. In Figs. 2 and 3, Plate CLXXXIX., is shown the external appearance of the machine as arranged when cutting spur gearing. The post A, with its projecting arm B, carrying the cutter head C, is made to swivel or turn between its base-plate and the cap which carries the driving pulley D, so as to set the arm B either parallel to the axis of the wheel to be cut for spur gearing, or at an angle to it for bevel gearing. It is also adjustable to any required position on the bed. Motion is conveyed to the cutter-head spindle from the pulley D, by means of the bevel wheels, to the cone pulley at the top of the post, and thence by a belt over guide pulleys (one of which acts as a tightener) to the cone pulley at the back of the cutter-head, and thence by bevel wheels to the spindle. The cutter-head slides back and forth on the arm B, driven by a nut on screw E; this screw is stationary, the nut only revolving, and the train of gearing which moves the nut, or causes it to revolve, starts from the lower cone pulley, by bevel wheels, through a set of variable friction discs, to a shaft G, and by pinion G^1, through a sun and planet system of wheels H, to a gear wheel I, on the end of a shaft, which passes through the arm B below and parallel to the screw, which shaft terminates in the square end (for handle) J. Spur wheels convey motion from this shaft to the revolving nut on the screw E. Upon the screw E are two nuts K L, which are adjustable on the screw, and are readily clamped at any required position. These two nuts determine the length of stroke of the cutter-head, by means of a crank on the end of the screw within the post A; the turning of the screw one way or the other through a small portion of a revolution operates clutches within the post, which determine the requisite motions in proper sequence. Thus the screw being stationary during the travel of the cutter through the wheel, the revolution of the nut on the screw causes the advancement of the cutter-head, we may say, towards nut L; when the revolving nut comes in contact with this stationary nut L, a tooth in the revolving nut clutches with a tooth

on the stationary nut L, and turns it, with it the screw, and as both nut and screw are in consequence revolving in the same direction at the same time, the forward motion of the cutter-head ceases, and the rotation of the screw operates the device that is to start the next motion, namely, the running back of the cutter-head to its starting point. Here again it comes in contact with nut K, again ceases its lateral motion, and imparts a rotary motion backward to the screw, stopping the driving machinery last in operation, and putting in motion the machinery that turns the blank to present the next space to be cut; the completion of this last operation restarting the cutter into the work. Through the centre of the column A is a vertical shaft, which revolves continually in one direction. The bevel wheels shown at M are (by means of a clutch) held from turning, allowed to run loose, or are driven by the vertical shaft as may be required. We have mentioned the system of sun and planet wheels at H; the planet wheels are attached to a face-place N, and this face-plate to one of the bevel wheels at M. When the bevel wheels are held stationary, the sun wheel in the centre drives the outer wheel H, and thence the feed. If the bevel wheels run loose the feed stops, as there is no longer a point of resistance to drive it.

If a rapid rotation be given to the bevel wheels, they will drive the planet wheels around the centre one, and thus impart a rapid motion to the nut on the screw E, to carry the cutter back to its starting point; but when it has reached this point the wheels M are cut loose from this driver, machinery is put in motion within the bed, that by means of a crank, rack, and pinion at O turns the crank handle P, lifting the latch Q at each revolution. The number of turns of this handle are determined by a pin R being placed in one or the other of the holes shown in the face-plate, that controls a nest of gearing S. A cam on a shaft within the bed, upon the completion of the proper number of turns of the handle P, moves the clutch to clamp the bevel wheels M, and thus restart the feed. This completes the series of motions, a series that may have any one of its individual motions lengthened or shortened and yet not affect the others.

The failure of any one to act merely prevents the next one from starting, so that no evil can result to the work being done. The devices used in this machine are many of them contrivances first arranged for other machines. Thus the variable friction feed F is common to all machines built by this firm where such a feed is advantageous; it is used on all their lathes as a turning feed, and on their drill presses and their boring machines. The sun-and-planet system is an outgrowth of their drill press feed. The stationary screw with its nuts K and L, was first used in their cotter drill, to enable a fixed length of stroke at a constant rate of progression possible, and the clutching device within the bed is taken from the feed motion of their planer. Thus devices familiar to them in other ones have been brought together and harmonised in this remarkable machine. We may add that it is Messrs. Sellers' practice to cut all the gear used on their tools, even if it is machine moulded.

The last tool shown by Messrs. Sellers which we have to describe here is the drill-grinding machine, illustrated by Figs. 1 to 3, Plate CLXXXVII. This machine is arranged to grind either ordinary or twist drills, the shank of the drill under treatment being held in a chuck and the lip between jaws, as shown in the engravings. The grinding is performed by a small emery wheel running at 500 revolutions per minute, a handle shifting the spindle on which this disc is carried, so as to move it along the edges of the drill. The grinding disc spindle runs in bearings in a radial arm, which can be fed downwards as required by means of the adjusting screw shown in Fig. 1. The use of this tool ensures the thoroughly true grinding of the drills to the correct angle, and it is a labour-saving machine which deserves to be widely employed.

A point well worthy of the notice of English engineers and millwrights in connexion with Messrs. Sellers' exhibits is the extreme lightness of the belt pulleys they employ, both on the machines themselves, and on the main line and counter-shafts. To English eyes such pulleys look weak both in the rims and arms, but we are informed on good authority that a failure from weak-

ness is almost unknown with Messrs. Sellers' pulleys, and the enormous experience of the firm as millwrights is sufficient guarantee that the results of the practice are satisfactory. Of course the pulleys are proportioned with care, and a high quality of iron is used in their manufacture, while special arrangements are made for moulding them, the result being that they are so true when cast, that the amount of metal cut away in turning the rims averages only 4 per cent. of their weight. That the lightness to which we have above referred, so long as it does not involve weakness, is an important advantage—particularly when high-speed shafting is employed—cannot be denied, and we consider therefore that Messrs. Sellers' practice in this respect is worthy of careful attention in this country. Messrs. Sellers also showed at their stand specimens of their admirable couplings and hangers for shafting; these details also are well worthy of the attention of our millwrights.

Continuing our survey of the machine tools in the American section, we have next to notice those shown by Messrs. Pratt and Whitney, of Hartford, Connecticut. These were of a lighter class than those exhibited by Messrs. Sellers, and already noticed, but they were equally distinguished by good workmanship, and by the care bestowed upon the design of the details. Prominent amongst the machines shown by this firm were a set of tools of different sizes for producing set-screws of various kinds, studs, pins used in gun work, &c. In these machines the bar—which may be of round, square, or any other section—from which the screws are to be produced is put in through the hollow spindle of the headstock, and is fixed, when the desired length has been protruded, by the aid of a concentric or cone chuck. By a very ingenious arrangement a single lever at the back of the machine, by a simple to and fro movement, releases the chuck, leaving the bar free, feeds the bar forward to any desired extent, and, when returned to its original position, closes the chuck and re-clamps the bar.

Sliding on the bed of the machine is a revolving or "turret" tool-holder, the centre on which this "turret" turns being in a direct line with the centre of the spindle of the headstock. The "turret" carries the several tools required to complete the article which it is desired to produce. The slide carrying the turret is moved to and fro on the bed by a lever, the connexion with this lever being such that, during the return stroke, the turret is turned partly round, and the tool following that last used is brought into operation at the succeeding forward stroke. A cross slide fitted with a tool-holder, is also provided for cutting off the finished screw from the bar. These machines turn out their work with great speed and accuracy, and they are altogether of an exceedingly useful type.

Besides the set of tools of which we have just spoken, Messrs. Pratt and Whitney had a number of interesting exhibits, of which we can speak but briefly here. Thus there was a lathe or boring machine specially adapted for turning out very accurately pieces of work which require to be operated upon by several tools, and which have to be bored as well as faced, &c., such for instance as some parts of sewing machines, guns, &c. In this lathe the article to be operated upon is fixed in a concentric chuck carried by the spindle of the headstock, and it is so held until finished, the object being to avoid any slight change in the position of its axis which might result from taking it out and re-chucking it. The back stock of the lathe is replaced by a head carrying a horizontal spindle round which are mounted eight tool-holders, like the barrels of a Gatling gun. The height of this compound revolving tool-holder is such, that each tool, when at the highest point, has its centre line exactly coincident with the centre line of the main spindle of the headstock, and each tool when in that position can be advanced so as to be operated on the article fixed in the lathe. Thus the revolving tool-holder can be provided with tools for roughing out, "outlining," facing, boring (in two or three sizes), screwing, &c., each of these tools being brought to bear upon the work without moving the latter in its chuck. For producing certain classes of articles, this tool is of great value, and the work it turns out is exceedingly accurate. Of more general applicability is a little contrivance which Messrs. Pratt and Whitney have fitted to a drilling machine which they exhibited. This consists merely of a disc graduated round its periphery, and

so arranged with regard to the feed gear, that it is revolved as the drill is fed down. An index by the side of the disc gives the means of reading the graduations, the latter being arranged to show the downward feed of the drill in inches; and thus by merely reading the scale, the depth to which the drill has penetrated can be at once ascertained. For drilling blind holes to a certain depth this arrangement is exceedingly handy, and saves the trouble and loss of time attendant upon withdrawing the drill for the purpose of measuring the depth of the hole. The drill to which this neat little adjunct is fitted has several other good points, of which, however, we cannot give a description here. Another convenient little contrivance is an arrangement fitted to a planing machine by Messrs. Pratt and Whitney, for enabling the man in charge to readily reverse the motion of the table by hand, and thus to quickly adjust the length of cut. The same makers also showed a very good quadruple drill for light work; a small horizontal drill, very handy for some kinds of work; a copying machine, including some novel and excellent points of detail; a good milling machine, a very simple machine for grinding milling tools at any desired angle, and a shaping machine fitted with a very convenient form of vice, arranged to tip and hold the articles to be operated upon at any desired inclination. These tools were all well and accurately made, and they showed great ingenuity in their design and adaptation to special work.

Another firm whose exhibits occupied a prominent position in the American section was the Brown and Sharpe Manufacturing Company, of Providence, Rhode Island. This firm exhibited three of their screw machines, the largest of these machines being suitable for making from bar iron all kinds of set-screws and studs ordinarily used in an engineer's factory, while the smallest is adapted for turning out the smallest screws employed by gunsmiths, clock-makers, &c. It would be difficult to give a fair idea of the special peculiarities of these machines without describing them in detail, and to do this would require the aid of engravings. We must content ourselves, therefore, with stating that both the workmanship and design of the machines are excellent, and that they turn out exceedingly good work. The same remarks will also apply to the two milling machines exhibited by the same makers, one of these being intended for small and the other for larger work, and both being machines of a very useful type. In connexion with these machines, also, was exhibited a gear-cutting attachment, this apparatus having 13-in. centres, and a 20-in. dividing plate containing 4,294 holes. By this plate can be divided all numbers up to 75, and all even numbers up to 150. The same makers also show some of their patent cutters for the teeth of wheels, the peculiarity of these cutters being that each tooth or blade has the same section throughout, and the cutters can thus be simply sharpened by grinding the blades straight across their faces. In consequence of the constant section of the blades the grinding does not in any way modify the form of teeth cut, while the curved contour given to the blades insures the necessary clearance, the grinding reducing the diameter of the cutter over all. This cutter is a vast improvement on the ordinary forms.

The last group of tools we have to notice in the American section is that of Messrs. Stiles and Parker, of Middleton, Conn., this firm showing some very neat punching presses, &c., in which the height of the tool is adjustable by an eccentric turning within another, and also a very good hammer, of which the tup works between guides and is raised by a strap, this strap being wound on a small drum carried by a spindle, which revolves in bearings at the top of the guide standards. The drum is not fixed to the spindle, but is connected to it by a friction clutch, while it is released by the tup coming into contact with a stop, which is adjustable at different heights according to the stroke required. The pressure of the foot on a treadle brings the clutch into gear, and causes a stroke to be made. The tool is a very useful one for general use in a smith's shop.

Among the miscellaneous small exhibits in the American section few attracted or deserved more attention than the vice shown by Mr. Thomas Hall, of Massachusetts. We give on Plate CXCI., Figs. 3 and 4, a perspective view

and a section through the vice, showing the arrangement of the parts. With the help of the latter figure the construction of the tool will be clearly understood. The fixed jaw is shown at c, and is cast in one piece with the rectangular hollow block, through which the moveable jaw and its parts slide, and terminates in a disc, with a dovetailed circular recess, as shown at c^1 and c^2. The bedplate of the vice is circular, and dovetailed, to fit the similarly-formed recess in the stock of the fixed jaw. This bedplate is made in two pieces, as shown at a a, and a sufficient space between is left in the centre to set them in place easily; they are then tightened up by a slightly tapered steel key, but this is not driven so tightly as to prevent the free movement of the stock c^1 c^2 round its dovetail.

The forward end of the movable jaw d is provided with a circular block e^1. This block consists of two discs, connected by a saddle piece e^3. This is all cast in one piece, and is of such a width as to fit between the parallel sides of the ∩-shaped sliding piece which forms the continuation of the moveable jaw d, and the form of which is clearly shown in the perspective sketch, Fig. 3. This block is fastened in its place by two straps e^2, each of them the width of the disc e^1. The straps are fastened by a screw to the under side of the sliding block, and at the top they are hooked over a small pin, as shown. A lever is attached to the saddle piece e^3. By depressing this handle, as in the perspective view, two effects are produced. First, the vice—which, when the lever is horizontal, is free to turn—is locked, and second, the object put in the vice is firmly gripped. These results are obtained as follows:—A small pin k extends between the two discs e^1. Bearing against the under side of this pin is shown one end of a lever j, the other end of which engages under a piece h, of the form shown in Fig. 4. Another pin f is also placed between the two discs. To it is attached a long wedge bar f^1, parallel as far as the small projection, shown inside the top of the sliding block. A strong abutment d^1 bridges the spaces between the sides of the sliding block. Outside this is a light spiral spring l, acting always against a tail piece formed on h, and of sufficient strength to retain h in the position shown, providing there is opposing effort. Resting on the bedplate a is a rack bar i, with teeth corresponding to those of h. On depressing the lever e the pin f is drawn back, and pulls the enlarged end of the bar f^1 along with it. At the same time, as the pin k rises it ceases to hold the lever j, which then no longer prevents the teeth in the piece h from locking in the rack teeth. As the bar f is drawn back the enlarged end has to pass between the small projection inside the top of the sliding block and the toggle lever g g^1, the effect being to depress the latter, and to set up a powerful locking action on the jaws of the vice. At the same time h is pressed down, and, entering the teeth of i, seizes the stock c^2 upon the bedplate, and checks all further movement in this direction. The vice is so arranged that no dirt can enter it, as the tail piece of h and the lever j are wide enough to fill the space between the checks of the sliding block, and the opening under the disc e^1 may also be closed.

We have now completed our general survey of the machine tools (for working on metals) exhibited in the American section of the Machinery Hall. It will, we think, be seen from what we have said that the American exhibits of machine tools were of special interest, and that they were decidedly characterised by great originality of design. In this respect they were, in fact, distinguished beyond any other collection of machine tools at Vienna, each tool shown in the American section being a speciality of its makers, and embodying a greater or less number of ingenious devices, which distinguished it from the productions of other firms. The workmanship, too, of the various machines shown was excellent, and every care appeared to have been taken to insure accuracy. The only fault, in fact, which we had to find with the American machine tools is, that some of the frames were not what they should be. With a few exceptions—and notably Messrs. Sellers, whose frames are excellent—our American friends are apt to run a little wild in the matter of frames, and we miss in their designs the solidity and simplicity which distinguish the productions of our leading English firms. Hollow or cored frames are not so largely used in the United States as they are now with us, and the

ribbed frames which are adopted, although probably amply strong enough for their work, are apt to be distinguished by many unnecessary curves and twists, which certainly do not add to their rigidity, and which we cannot regard as lines of beauty. This is especially noticeable with the legs for supporting the smaller machines. In the design of machine framing there is, however, we believe a steady improvement taking place amongst American makers, and we expect that in a few years the productions of all the leading firms will be as good in this respect as they undoubtedly now are in other and perhaps more important details.

Although not directly connected with machine tools we know of no section of this report in which we can notice more appropriately than in the present one the cold rolled shafting which is so extensively employed on the other side of the Atlantic.

Messrs. Jones and Laughlins, of Pittsburgh, Pennsylvania, exhibited at Vienna samples of the manufacture which they have made a speciality, cold rolled iron for shafting, piston rods, the finger bars, knife backs, and guard bars for reaping and mowing machines, &c. The use of this material for these, and other purposes, has long been general in the States, and it is maintained by the manufacturers, and the assertion is borne out by numerous experiments and long experience, that the process adopted increases the strength, the hardness, and the elasticity of the metal in a very marked degree. The manufacture is an exceedingly simple matter, the bars are rolled hot to within about one-eighth of an inch of their ultimate size, are then placed in acid, to remove the surface impurities, and are finally reduced to the ultimate dimension by the special process of cold rolling. The bars thus made have a highly polished and perfectly smooth surface, and are as true as if turned in a lathe.

It may be found of interest to publish a summary of the principal experiments which have been made to test the properties of the iron, though none of the tests are of very recent dates. The first series of experiments were conducted by Mr. W. Wade, of the United States Ordnance Department, and the summary of about 60 tests is given in the subjoined Table No. 1. The cold rolled iron was in each case compared with precisely the same class of bar iron produced in the usual way.

TABLE I.

	Iron rolled while		Ratio of increase due to cold Rolling.	Average Rate of Increase per cent.
	Hot.	Cold.		
1. Transverse Strains:	lb.	lb.		
Bars supported at both ends, distance of bearings 30 in., load applied in the middle.				
Weight which gave a permanent set of one-tenth of an inch to:—				
1½ in. square bars	3,100	10,700	3·451	162½
Round bars, 2 in. in diameter	5,200	11,100	2·134	
Round bars, 2½ in. in diameter	6,800	15,600	2·294	
2. Torsion:				
Weight applied at a distance of 25 in. from the centre of the bar, capable of giving a permanent set of one degree.				
Round bars, 1½ in. in diameter, and 9 in. between the points of attachment	750	1,725	2·300	130
3. Compression:				
Weight giving a permanent set of one-hundredth of an inch to columns 1½ in. long and ⅝ in. in diameter	13,000	34,000	2·615	161½
Weight giving a permanent set to columns 8 in. long, and ¾ in. in diameter:				
Puddled iron	21,000	31,000	1·476	64
Charcoal bloom iron	20,500	37,000	1·804	

Table I.—*continued.*

—	Iron roller while		Ratio of increase due to cold Rolling.	Average Rate of Increase per cent.
	Hot.	Cold.		
4. Tension:	lb.	lb.		
Weight per square inch, giving a permanent set to rods ¼ in. in diameter:				
Puddled iron	37,250	68,427	1·837	95
Charcoal bloom iron	42,439	87,396	2·059	
Breaking weight per square inch for the same rods:				
Puddled iron	55,760	83,156	1·491	72
Charcoal bloom iron	50,927	99,203	1·950	
5. Hardness:				
Weight required to produce equal indentation	5,000	7,500	1·500	50

The second series of experiments was made by Mr. John C. Whipple, Chief Engineer of the United States Navy, for tensile strength, and the following Table gives the abstract of results obtained.

Table II.

Quality of Iron.	Sectional Area of Bar tested.	Breaking Weight of Bar.	Breaking Weight per Square Inch.	Increase of Strength in polished Iron.
	sq. in.	lb.	lb.	lb.
Polished iron	·1824	19,125	104,852	
Black iron	·4249	22,750	53,541	51,311
Polished iron	·1712	16,875	93,100	
Black iron	·4515	27,000	59,797	33,403
Polished iron	·1589	13,125	82,600	
Black iron	·4249	22,750	53,541	29,059
Polished iron	·1844	20,750	112,527	
Polished iron	·1855	21,250	114,555	

The following results were quoted in the report by the Franklin Institute of Philadelphia on the twenty-sixth exhibition of American manufacturers.

Table III.

	lb. per sq. in.
1. Tensile strength:	
No. 1. Inferior quality, broke at	49,510
Same bar, cold rolled	66,862
No. 2. Ordinary bar, broke at	57,350
Cold rolled	92,623
2. Resistance to torsion:	
No. 3. Round black bar, $1\frac{5}{16}$ in. diameter. Length of lever 25 in.; twisted with a strain of 587½ lb.	
Cold rolled, same quality, $1\frac{1}{4}$ in. diameter. Length of lever 25 in.; twisted with a strain of 1,000 lb.	

Experiments were also made by Sir William Fairbairn confirming the previous results, and showing a comparison of the cold rolled with turned bars. A brief summary of these tests is subjoined:

Table IV.

Condition of Bar.	Area of Bar.	Breaking Weight of Bar in Pounds.	Breaking Weight per Square Inch.		Strength: Untouched Bar being Units.
			lbs.	tons.	
Untouched (black)	·85873	50,346	58,628	26·173	1·000
Rolled cold	·7854	69,295	88,230	39·388	1·500
Turned	·7854	47,710	60,746	27·119	1·036

The whole of the tests which have been made, and of which the foregoing are extracts, tend to show conclusively that the strength of the bars is increased by the process of cold rolling adopted by Messrs. Jones and Laughlins, whilst the long and extensive use of this shafting in the United States appears to justify the claims of the manufacturers that their cold rolled is superior in many respects to turned shafting.

Great Britain.

Leaving the American collection, and passing on to the British section, it was impossible not to be struck by the different character of the exhibits. In the American department almost every tool possessed some novel feature, and each was distinguished by an individuality which showed it to be the special design of its maker; while in the British section the great majority of the tools were reproductions of old and well-known patterns, possessing scarcely any interest whatever as exhibits. Messrs. Sharp, Stewart, and Co., of Manchester, showed, it is true, a collection of tools which, as far as good design and workmanship were concerned, were all that could be desired for; but we could have wished that the exhibits of this firm had been accompanied by others from our other leading makers.

The most conspicuous exhibit at Messrs. Sharp, Stewart, & Co.'s stand was the fine planing machine which we illustrate on Plate CXC., Fig. 1. This machine, which will plane 8 ft. long by 3 ft. 4 in. wide, is constructed on Sellers' system, the table deriving its motion from a worm gearing into a rack on its under side. The worm is carried by an oblique shaft, this shaft being placed so that the angle between its centre line and that of the table is equal to that corresponding to the pitch of the worm. The effect of this is that an ordinary straight-toothed rack can be employed, while an arrangement is obtained which gives very moderate frictional resistance, and which has been proved by a lengthened experience to have remarkable powers of withstanding wear and tear. In fact, as we have already mentioned when speaking of the exhibits of Messrs. Sellers at Vienna, the worm in planing machines made on their system, needs no lubrication beyond the oil which looks on to it from the adjoining bearings of the worm shaft.

The machine now under notice has the ingenious belt gear to which we have before alluded as being employed by Messrs. Sellers, the two straps (one open and one crossed) necessary for driving the machine being, at each reversal, moved successively instead of simultaneously. The effect of this is, of course, that the lateral traverse of the belts needs to be but about half that necessary under the ordinary system; and thus while the wear and tear of the belts is reduced, much narrower pulleys can also be employed. In the planing machines made by Messrs. Sellers themselves, the belt pulleys are arranged so that their shaft is parallel with the centre line of the machine, the latter thus having to be arranged in a workshop in a line with the lathes, &c. This we believe to be really the best way to arrange planing machines; but Messrs. Sharp, Stewart, & Co., to meet, we presume, the general fashion in this country, have modified Messrs. Sellers' arrangement, so as to place the belt pulleys in the same position as in ordinary planing machines, namely, with their shaft at right angles to the direction of motion of the machine table. Another detail in which Messrs. Sharp, Stewart, & Co.'s planing machine differs from the Sellers machine is the mode of lifting the tools during the return stroke. The arrangement employed by Messrs. Sharp, Stewart, & Co. is shown by Fig. 1, Plate CXC.; that adopted by Messrs. Sellers we have already described.

The machine under notice is, as will be seen, fitted with three tool-holders, two of these being situated on the cross slide, and the third being fitted to a slide which can be raised or lowered on one of the side pillars. A tool thus mounted is very convenient for many classes of work. The general design of the machine is, as will be seen from the illustration, very massive and substantial, while the care paid to points of detail, and the workmanship throughout, fully sustained the reputation the makers have long had for this class of work.

Another very good tool shown by Messrs. Sharp, Stewart, & Co. was a double shaping machine, the leading characteristics of which will be understood on reference to the view of the shaping machine by the same firm given on Plate CXC., Fig. 2. The machine illustrated is similar to that exhibited by the firm at Vienna, with the exception that the latter machine had a somewhat longer bed, and was provided with two headstocks, these two headstocks having independent driving gear. A good feature in this machine is the provision of a stiff longitudinal girder, which extends from one leg of the machine to the other a short distance above the floor level, and affords an excellent support to the tables for carrying the work. The machine at Vienna was also furnished with a bridge piece spanning the space between the two tables, this bridge piece being fitted with a vertical slide, useful for supporting some kinds of work which can be conveniently placed on the central mandril. The machine at the Exhibition was of a very substantial pattern, and had the details well proportioned and conveniently arranged, while the workmanship was excellent throughout.

Messrs. Sharp, Stewart, & Co. were also exhibitors of a very fine heavy slotting machine) illustrated on Plate CXC., Fig. 4), of a large double slot-drilling machine of very neat and substantial design; of a machine for drilling railway wheel tyres and of one of Sellers' screwing machines. This latter machine was adapted for screwing bolts up to $\frac{3}{4}$ in diameter, and it is illustrated on Plate CXC., Fig. 3. It consists of the bed, to which is cast the headstock; the spindle carrying the driving pulleys on one side, and the screw-dies box on the other side, passes through the head stock. The sliding rest, into which the bolt to be cut is fixed, is shifted by a movable handle, which is provided with pawls at the end, gearing into racks inside, and at the bottom of the slide bars of the bed. By means of this sort of ratchet motion, the slide rest, with the bolt to be cut, is pressed forward, until the dies have firmly gripped the bolt, when the cutting is accomplished without any further attention of the workman, the slide rest being drawn forwards by the motion of the screw. The slide rest is provided at the side with a projecting bracket, the end of which passes over a rod connected with a lever; on this rod a small sliding bush may be fixed at any position according to the length of the screw to be cut. When the end of the bracket of the slide rest pushes against the sliding bush, the lever is forced back, and turns a shaft, which passes through the bed, and which is connected by another lever inside the bed with a cone which forces the screw dies off the screw, thus allowing the bolt with the slide rest to be drawn back, during which manipulation, of course, the lever has to be forced back by hand. This is, however, easily done, as the workman can do so with his left hand, whilst he draws back the slide rest with his right hand. These machines, which finish the screws with one cut, are very convenient, and are built by Messrs. Sharp, Stewart, & Co., Limited, in various sizes, the largest being capable of cutting bolts up to 3 in. diameter.

The only special tool at Messrs. Sharp, Stewart, & Co.'s stand was one of Mr. F. W. Webb's machines for slotting the insides of the rims of wrought-iron railway wheels a tool which we illustrate on Plate CXCI., Fig. 1. In Mr. Webb's machine the tool is mounted in a holder provided at one end of a vibrating lever, the other end of this lever being slotted, and being fitted with a sliding block, into which the pin of a disc crank enters. As the crank disc revolves with its upper edge approaching the fulcrum of the lever, the effect of the arrangement is to give the toolholder a slow downward and a quick return stroke. The point of the tool, of course, describes an arc of a circle struck from the centre of the fulcrum on which the lever oscillates; and it can thus, as shown in the engraving, be employed for giving a curved form to the inner periphery of a wheel rim. It will be also seen that the toolholder is capable of revolving in the end of the arm, and thus on reaching a spoke of the wheel it can be rotated by the worm wheel and worm shown, and the tool thus made to cut the arc joining the rim to the spoke.

The wheel to be operated upon is fixed on a table, which is mounted on a bed similar to that of a lathe, and which is provided with both traverse and circular motions, the latter being self-acting. When large wheels are being

slotted, the rim is supported near the point where the cut is taking place by introducing beneath it a roller carried by a standard fixed to the bed of the machine. In our engraving a small wheel is shown in position, and the supporting roller and its standard are represented as shifted temporarily to the outer end of the bed. Altogether this is an exceedingly well-designed machine, and the example shown at Vienna by Messrs. Sharp, Stewart, & Co., was an excellent piece of work. One of those machines has been in use at the London and North-western Railway works at Crewe for some years past, and has done excellent service.

Two large exhibitors of tools in the British section were Messrs. Henry Hind and Sons and Messrs. New, both of Nottingham. Of two of Messrs. Hind's exhibits we give illustrations on Plate CXCI., Figs. 2 and 6. Of these the first is a slotting machine with 9 in. stroke, and adapted for taking in articles 48 in. in diameter, while the other is a wall drill of a convenient type. This latter machine is double geared, and will drill holes up to 6 in. in diameter, while the frame being fitted with moveable feet it can be fixed at any desired distance from a wall or column. A self-acting feed motion is provided, the spindle having a range of 10 in. Machines of this kind are exceedingly handy in a number of situations where the floor space for an ordinary drilling machine is not available, and the example now under notice is a very good one of its class.

Of Messrs. Hind's exhibits we need only remark here that these tools were generally substantial, and they will no doubt turn out good work, but they many of them lacked the high finish which we are apt to expect in the exhibits of English tool makers. The same remarks will also apply to Messrs. New's collection, the principal tools in which were a very heavy railway wheel lathe and a carriage axle lathe, the designs for both these machines originating, we believe, from Mr. W. Stroudley, the locomotive superintendent of the London, Brighton, and South Coast Railway, for whom Messrs. New made similar tools some little time ago. Both these machines were substantially built—the wheel lathe especially being of a very massive type—and both were well made. Messrs. New's other tools were of ordinary patterns, and do not call for special remark.

Steam hammer makers were very fairly represented, in the British section at all events, as far as the smaller sizes of hammers were concerned. Messrs. Massey and Co., of Openshaw, near Manchester, and Messrs. Davis and Primrose, of Leith, were both exhibitors of their well known and very useful types, while Messrs. Thwaites and Carbutt of Bradford were represented by the 7 cwt. hammer which we illustrate on Plate CXCII. This hammer has been specially constructed for tilting steel, work which requires the blows to be delivered continuously in very rapid succession, rather than slowly and heavily, as with ordinary hammers. This machine is intended to deliver (with steam having a pressure of 60 lb. per square inch), as many as 400 blows per minute, but its ordinary speed will probably not exceed 300 blows. In order to work at such a speed, it has been necessary to make the hammer self-acting, but it is so constructed that it can also be worked by hand if required. The hand lever behind the framing regulates the length of the stroke through a triple-ported piston valve. This lever can be used for working the hammer by hand, but under ordinary circumstances it is made fast in the position corresponding to the desired stroke, and the bevelled slot in the front of the tup opens and closes the valve at the right time. The two levers in front of the framing are connected with two piston valves in a separate casing, which regulate the amount of steam allowed to pass through the main valve to the two ends of the cylinder, and in this way determine the force of the blow. The piston and rod are of solid steel. The hammer is strongly and simply constructed.

Messrs. Thwaites and Carbutt were also the exhibitors of one of their Root's blowers driven by an engine constructed on the same framing as shown in Plate CXCII., the arrangement being one designed by Mr. F. W. Webb, of Crewe. The blower shown was a "No. 7" capable of delivering about 10,800 cubic feet of air per minute, the speed being about 300 revolutions per minute. The arrangement exhibited was first designed for the West Cumberland Hematite Iron Works, to which works Mr. Webb was consulting engineer; but it has since been applied at several other works with very satisfactory

results. The arrangement is, as will be seen, very compact and convenient. Messrs. Thwaites and Carbutt have now made a very large number of Root's blowers for use in this country and on the Continent, and their use is rapidly extending.

Besides a good collection of rolled-bar, cold-blast pig, and refined iron, railway tyres, axles, &c., the Kirkstall Forge Company, of Leeds, exhibited at Vienna a 50 cwt. and a 3 cwt. single and double action Naylor's steam hammers, illustrations of which are given on Plate CXCI., Fig. 5, and Plate CXCIII., Fig. 8, respectively. The smaller hammer shown by Fig. 8, Plate CXCIII., has a single frame, the bedplate of which is 3 ft. square, while the height from the base to the under side of cylinder is 5 ft. 4 in.; the hammer is double acting and automatic, and is provided with a hand-worked cylindrical throttle valve, which regulates the amount of steam, by means of which the force of the blow is determined. The automatic action of the hammer is effected by sliding wedges in the side of the frame, the position of which wedges can be altered by a lever passing through them, as shown in the illustration; a pin fastened to the block strikes against these sliding wedges, and, according to their position, changes the stroke by means of a lever acting on two piston valves. These valves, however, do not work in a vertical direction only, but they may be turned round horizontally, thus allowing a greater or less amount of steam to enter the cylinder, and taking thus the place of the throttle valve in controlling the force of the blow. For this purpose the valve-rod carries a lever, which moves in a horizontal direction, so that the whole of the hand gear is completely under control, and is easy to work in any position. The rapidity of the stroke obtained by this arrangement is advantageous for forgings requiring a great number of blows, and for finishing the work at one heat. The diameter of cylinder is 9 in., and the maximum stroke is 18 in. The hammer can be worked up to a speed of 200 strokes per minute, whilst the power can also be adjusted instantaneously. The Kirkstall Forge Company manufacture these hammers in various sizes, from 30 lb. up to 50 tons; the smaller ones, ranging to 15 cwt., being particularly adapted for smiths' work, and the larger sizes for heavy forgings. We may mention also, that the Kirkstall Forge Company also exhibited in motion a small model hammer of ordinary construction, weighing 25 lb., and the workmanship of which is excellent.

The machinery represented in Figs. 1 to 7 on Plate CXCIII. was exhibited at Vienna by the patentee, Mr. D. Davies, of Viaduct Works, Crumlin, Newport, Monmouthshire. It is unique of its kind, and deservedly attracted a good deal of attention in the Exhibition. It is intended for all kinds of small forging work about a smithy, for which the steam hammer is scarcely suitable; but an examination of the engravings will show better than any lengthened statement of ours the kind of work for which it is most adapted. The machine may be described shortly as a tilt hammer worked direct by a steam cylinder (the blows being controlled by a foot lever), and capable of being turned round by a simple apparatus so as to deliver the blows at any angle to the anvil.

In the engravings, Fig. 1 is a front elevation of the machine; Fig. 2 is a vertical section through the line A A in Fig. 3; Fig. 3 is a sectional plan on the line, B B in Fig. 2; Fig. 4 is a vertical section through the valve-chest and turning gear, and Fig. 5 is a section at D in Fig. 2. Figures 6 and 7 also show a side elevation and outside plan of the machine. The arrangement of the striking gear is as follows: The hammer shaft itself, which works on a fixed pin, 2⅛ in. diameter, is connected at its hinder end with a pin in the lower end of a short connecting rod. This rod is free to vibrate in a large slot made in what may be called the piston rod head, and is compelled by a pin at its upper end always to follow the movements of the piston rod, which moves up and down in the guide shown in plan in Fig. 5. The steam cylinder itself (the part of the rod in which is 3 in. diameter), is 6 in. diameter, and has a maximum stroke of 5 in., corresponding to a movement of the hammer head five times as great. A lug at the top of the piston rod head carries a spindle (seen in Figs. 1 and 4), and compels it always to follow the motions of the piston. Lower down this spindle becomes a frame, in which

is a curved slot, and this slotted frame works up and down as the piston rod moves across the spindle of the little double-piston steam distribution valve seen in longitudinal section in Figs. 2 and 3. From Fig. 3 it will be seen that the valve spindle has attached to it a slotted head, through which the above-mentioned frame can work. Through this slotted head a pin is fastened, passing through the slot in the moving frame, and the curved sides of this slot, pressing upon the pin in one or the other direction, give the required motion to the valve. The construction of the valve, and the arrangement of the ports, are clearly shown on the drawing, from which also it will be seen that one pipe, divided into two by a partition, and placed like a trunnion in the centre of rotation, serves for both steam and exhaust. The steam is always pressing on the two internal surfaces of the pistons, so that the valve is in equilibrium, and is admitted to the two ends of the cylinder alternately, the hammer being double-acting, while the exhaust passes out past the outside sides of the pistons, and through the other half of the trunnion pipe.

The machine consists of two principal castings, of which one, which carries the hammer, and contains the cylinder and the whole of the working parts, rests in two bearings in the other, which is the frame. These bearings are respectively 2 ft. and 1 ft. diameter, a size which is necessary as well to admit the proper play of the hammer, and room for the valve, as to secure steadiness to the whole machine, while the object of arranging the machine in this way is to allow the hammer to strike at any desired angle. For turning the hammer round, worm gear, Fig. 4. worked by a hand wheel, is provided, and in consequence of the steam and exhaust pipes being both admitted through the centre of rotation, the distribution of the steam is not in any way affected by the position of the valve, which must of course turn round along with the rest of the casting above referred to. The hammer is set in motion or stopped by a foot lever, Figs. 6 and 7, which works a stop-valve (shown in dotted lines in Fig. 7,) placed below ground in a convenient position for the man working at the anvil. The striker can be worked with a pressure of 35 lb. steam, but 60 lb. or 70 lb. is more advantageous; it can also be arranged to work either with water or compressed air in situations where these agents are preferable to steam. It can deliver from 300 to 400 blows per minute.

The only other exhibitors of tools in the British section were Messrs. C. De Bergue & Co., who showed some of their well-known punching, and shearing, and rivet-making machines, these being all of good design and workmanship.

Altogether the collection of machine tools in the British department but very poorly represented the progress of this branch of engineering in England, and to all who were familiar with the numerous admirable special tools to be found in our leading engineering factories, the British exhibits of this class at Vienna could not fail to be most disappointing. We know that during the year 1872 English tool makers were extremely busy, and were almost without exception in arrear with their orders in hand; but we, nevertheless, cannot but regret that they should, as a body, have been so inadequately represented at Vienna.

France.

France we found even more inadequately represented than England in this important branch of mechanical industry, the only French exhibitors of machine tools being Messrs. Dandoy-Mailliard, Lucq & Co., of Mauberge. This firm showed a number of tools, but most of them were of small size and very ordinary types. The frames, too, were generally too light, according to English ideas, while almost the only distinguishing feature was that a number of the drilling machines were made with vices attached to the backs of the pillars or standards, the frames of the tables being in some cases extended back past the pillars to carry these vices. The arrangement is a convenient one in many cases. We also noticed at this stand some handy little punching and shearing machines, in which the rams are worked by a long hand lever, the machines being intended for use in small shops, such as country smithies, &c., where steam power does not exist.

Switzerland.

In the Swiss and Belgium sections there were also very few machine tools, the only exhibitors in the former department being Messrs. J. J. Reiter and Co., of Winterthur, and M. Rudolf Iäcklin, of Basle. Messrs. Rieter's collection included some good substantial tools, the most prominent being a heavy slot-drilling machine, in which the head carrying the drill spindle slides to and fro on the face of a kind of bridge connecting the heads of a pair of massive standards. The movement of the spindle slide is effected by a connecting rod coupled to a crank disc which revolves in a recess in the face of the bridge girder, The design of this machine, which is illustrated on Plate CXCIV., Fig. 6, appears a novel one, and it possesses some good points. There was also at the same stand a heavy radial drilling machine, illustrated on Plate CXCIV., Figs. 1 to 3, and distinguished by some special points of detail, a band-sawing machine for iron illustrated on Plate CXCIV,, Figs. 4 and 5, and some other machines of ordinary types and good workmanship. The other Swiss exhibitor, M. Rudolf Iäcklin, of Basle, showed a good collection of small machines for working tin, copper, or brass plate, the set including rollers for fluting and flanging, a planishing machine, and other tools, many of them possessing ingenious features.

Belgium.

Belgium was represented in this section solely by Messrs. Bede & Co. (formerly Société Honget et Teston, of Verviers). At Messrs. Bede's stand the two principal tools exhibited were a double boring machine and a multiple drilling machine with four spindles. Of the former machine illustrations are given on Plate CXCV., Figs. 1, 2, and 3. This tool is intended for boring simultaneously the two ends of coupling or connecting rods, or similar details, or it may be used for boring small cylinders, either a pair of cylinders, or the barrel and valve spindle stuffing-boxes of a single cylinder, being operated upon at one time. The machine is also available for facing, disc tool-holders, being in this case fixed on the boring bars. The machine consists, as will be seen, of a substantial bed, 5·100 metres (16 ft. $8\frac{3}{4}$ in.) long, this bed having mounted upon it a pair of boring heads each furnished with independent driving gear. These heads can be approached towards or withdrawn from each other by the screw shown in the plan this being divided at the centre and each half being capable of being operated separately. Similar screws in the front of the bed (see Fig. 1) give the means of adjusting the pair of tables on which the work is carried to any required distance apart. The maximum and minimum distances apart at which the centres of the two boring bars can be placed are 4·500 metres (14 ft. 9 in.) and 0·55 metres (1 ft. $9\frac{5}{8}$ in.) respectively.

The boring heads are, as will be seen, provided with double gear, and the forward feed of the boring bar of each head is given by a screw and differential feed gear as shown. The counter wheels of this differential gear run have on a fixed stud which is situated in a line with the counter spindle of the boring head, and the outer wheel of this gear has attached to it a cone pulley from which a belt extends to a corresponding cone pulley on a shaft running across the end of the machine a short distance above the floor level. This shaft drives by bevel gear a corresponding shaft running along the front of the machine, this shaft carrying two cone pulleys as shown. From each of these cone pulleys there can be driven direct the screw which gives the lateral traverse to the cross slide on the corresponding table, this lateral traverse being required when the machine is used for facing.

The shaft which we have mentioned as running along the front of the machine also carries a couple of worms while each table is provided with a vertical spindle having a worm wheel into which one of these worms gears. At the top of this spindle is a bevel wheel which gears into a corresponding bevel wheel on a spindle which extends under the cross slide to the front of the table, where it carries a pinion by which it can be geared with the screw for giving a longitudinal traverse to the slide. The raising and lowering of the tables

can be effected by hand by means of a vertical screw actuated by a horizontal spindle and bevel gear. The arrangement of the self-acting feed-gear, necessitating as it does different lengths of straps for the various positions of the boring heads and slides on the table, is scarcely so convenient as it might be; but the proportions of the machine are good. The remaining details will be readily understood from the engravings, on which the principal dimensions are also all given in metrical measures. The tool, we may add, was very well made, and, as will be seen, it is applicable to a great variety of work.

As regards Messrs. Bede's multiple-drilling machine, we need merely state that the spindles, which are driven by skew gear, are adjustable to variable distances apart, and that the machine generally is of a substantial type. The other machines shown by Messrs. Bede require no special notice.

Sweden.

Sweden was represented in the class of exhibits of which we are now speaking by Mr. Th. Munktell, of Eskilstuna, who showed a small three-spindle drill for light work, and a small screw-cutting lathe. These tools were both well made and of good design; but the patterns had a strong appearance of having been, to some extent, copied from American originals. The countershaft of the lathe, we noticed, was carried by hangers of Messrs. Sellers' type, and in place of shifting the belts, friction clutch pulleys, of the pattern made by the Brown and Sharpe Manufacturing Company, of Providence, U.S., were used for stopping and starting. In pointing out these facts we by no means desire to disparage Mr. Munktell's exhibits. The expedients adopted are good, and they deserve to be used in Sweden as well as in America, while, as we have said, the tools exhibited were well made.

Germany.

Germany was a very large exhibitor of machine tools at Vienna, in fact the exhibits of this class to be found in the German section of the Machinery Hall probably outnumbered those of all other nations put together. Of course in such a large collection, made up as it was of the exhibits of a number of manufacturers, there were things to be condemned as well as others to be praised; but taken as a whole, the German machine tools were highly creditable, and certainly showed material progress in this branch of engineering.

A prominent collection of exhibits of this class in the German section was that of the Sächsische Maschinen-Fabrik zu Chemnitz, formerly Richard Hartmann. Of several of the machines exhibited by this firm we must speak in some detail, and we may commence with the railway wheel turning lathe illustrated on Plate CXCVI., Fig 1. The peculiarity of the machine consists in its having no mandrils, in the ordinary sense of the word; strictly speaking, it may be called a lathe with fixed mandrils of an unusually large diameter. The diameters of the wheels which will be turned in such a machine as the present differ so little that it is fitted only with single gear in the pinion and spur wheel *a* and *b*. The latter is fast on a shaft which runs right along the machine from end to end, and by means of two pinions drives the racks on the back of the face plates, *c c*. The headstocks *m m*, which are of the simplest possible construction, have cast on them the brackets *e e*, which being turned throughout part of their length serve as mandrils for the face plates to revolve upon. A collar or flange on the front of each mandril keeps the face plates in place, and in order to go over this collar each is made in halves and bolted together. The face plates revolve quite freely on the mandrils, and even if they do not revolve quite truly the accuracy of the turning is in no way affected, as they merely serve as drivers for the wheels. In the front of the mandrils *e e* are brackets *d d*, containing V-shaped brasses adjustable by screws top and bottom, and in these brasses the journals of the axle revolve, there being no centres of any kind. In the centre of each headstock there is, however, a pin which (by screw gear and a hand-wheel, concealed in our engraving by the side of the headstock) can be set up against the end of the axle. This pin has nothing to do with the centreing of the work, but is

intended merely to take any side thrust which there may be, so that the brasses *d d* act merely as bearings.

The arrangement for taking out the axle is very simple; the covers *f f* of the bearings work at one end on pins, and are held down at their other ends by frames *n n* with screws. To take out the axle it is only necessary to loosen these screws, and the frames can be at once turned down, the caps *f f* thrown back, and the axle lifted away. The two slide rests *g g* work half upon one side of the main bed plate and half upon an outer frame which is cast along with it. They have the usual feed and traverse motions, all of which can be made self-acting by chain gear from the crank *h*, which is driven off the pulley shaft by a worm and worm wheel. Gear is provided for shifting up the right-hand headstock to suit axles of different lengths between the journals. The handle seen in front of this headstock is for the purpose of throwing in and out of gear the pinion which turns the face plate.

This type of machine has several advantages, the most noticeable one being its extreme simplicity; we should not be surprised to see it largely adopted. The maximum distance between the inner faces of the brackets *d d* is 2·25 metres (7 ft. 4½ in.), the height of the centres 580 mm. (22·83 in.), and the diameter of the face plates 1·2 metres (3 ft. 11¼ in.). The weight of the whole machine is 7 tons.

Next we may describe the large boring and slot-drilling machine exhibited at Vienna by the same firm, this machine being represented by Fig 2, Plate CXCVI. It is a heavy machine, but well proportioned and adapted for the work for which it is intended. The bedplate *a* is 5·00 metres (16 ft. 5 in.) long, and 960 mm. (3 ft. 1¾ in.) wide. On it slides the standard *b*, the foot of which is 1·35 metres (4 ft. 5 in.) long. The standard itself has a vertical face 1·16 metres (3 ft. 9½ in.) long, traversed by a slide *c*, 630 mm. (2 ft. ¾ in.) deep. The machine is driven (either in single or double gear) by a five-speeded cone at *e*, giving motion to the horizontal shaft *f*. When the machine is used for boring only, the wheels, shown at the left-hand side of the engraving, are all out of gear, and motion is transmitted through the bevel gear *g* and *h* to the clutch *n*, which can be geared with the pinion *i* (this pinion running loose on its spindle), and thence through the spur wheel *k* is driven the tool spindle *d d*. The feed can either be by hand, by means of the hand-wheel *l*, or can be made self-acting by means of the four pairs of wheels *m m*, either pair of which can be thrown into gear at pleasure. They differ slightly in size, so as to give an alternative speed of feed, and two of the pairs are for the forward, and two for the backward motion of the tool. To draw the tool quickly backwards the hand wheel *l* is used, the pinion *i* being thrown out of gear by means of the lever *p*.

To use the machine as a slot drill either the standard *b* must slide on the bedplate, or the slide *c* must travel on the standard according as the slot lies horizontally or vertically. Both these motions are made self-acting, and can be set in action by the clutch-gear *q* the arrangement of which will be easily understood from the engraving. For the motion of the standard along the bedplate the train of wheels *u u* is employed, and these, by means of the horizontal screwed spindle *s*, move the standard in the usual way. When the vertical motion of the slide is desired, the change wheels *u u* are geared with the spindle *t*, instead of with *s*, and this, by means of bevel gearing, works the vertical screw *v*, which turns in a nut behind the slide *c*. By means of the cross-handle *z*, which fits either *s* or *t*, either the horizontal or vertical motion can be given by hand if desired. The motion is to right or left, upwards or downwards, according as the clutch *q* is brought into gear with one or other of the pinions on each side of it.

The next machine for notice is one illustrated by Plate CXCVI., Fig. 3. This machine, by the same makers as the above, is intended for the purpose of drilling, from the inside, the holes in the tyres of railway wheels. The axle, with its wheels in place, rests on the two supports shown on the bed of the machine. The tool is fixed in the upper part of the small toolholder on the left of the main slide. It receives its rotary motion by bevel gear very similar to that of an ordinary drilling machine, and it can also be moved from side to

side, through a distance of 6 or 7 in. by hand. On the back of the horizontal spindle which crosses the top of the machine is a small two-speeded pulley, which transmits its motion to another similar pulley on a spindle below, and then by means of a worm and worm-wheel—(seen in the engraving on the right of the machine)—to a cross spindle. On the inner end of this spindle is a bevel pinion driving in opposite directions two similar pinions which revolve round the vertical screw. By means of a clutch, actuated by a small hand lever behind, either the one or the other of these pinions can be brought into gear, and thus the tool is fed upwards, or withdrawn from the hole downwards, by a self-acting motion. The cone which drives the whole machine is triple speeded. The machine can drill wheels from 2 ft. 6 in. diameter upwards, and must be very convenient in a shop where much of such work is done. It was thoroughly well made throughout.

A very prominent exhibit in the collection of the Sächsische Maschinen Fabrik (formerly Richard Hartmann), of Chemnitz, of which we are now speaking, was the large plate edge planing machine illustrated by Figs. 5 and 6, Plate CXCVI. This machine consists of the bed, the frame, and the table for receiving the plates. The bed is similarly constructed to that of a lathe, and carries a slide rest with the tool box, which has to be worked by hand, whilst the slide rest is drawn along the bed by means of a double-threaded screw 4 in. in diameter, with threads $2\frac{1}{4}$ in. pitch and $\frac{9}{16}$ in. deep. This screw receives its motion from the pulleys and the wheel gear on the left-hand side of the machine, and the forward and backward travel of the slide rest with the tool-box is simply effected in the same manner as on ordinary planing machines, the slide rest touching at the end of its travel against adjustable stops fixed on a shaft placed in front of the bed, and this shaft carrying at one end the fork for the shifting of the belt from one pulley to the other. The bed is 21 ft. 7 in. long, and 22 in. high.

The frame for the fastening of the plates is a strong cast-iron structure of the same length as the bed, allowing plates of 5·400 metres (17 ft. $8\frac{5}{8}$ in.) in length, and $12\frac{1}{2}$ in. in thickness, to be fixed by eleven $1\frac{1}{2}$ in. screws; the top girder has a depth at the centre of 2 ft. $4\frac{1}{2}$ in. The table at the back of the machine for the support of the plates projects 4 ft., but does not run along the whole length of the frame, it being divided into three sections, the distances between the sections being equal to the length of a section of the table. The whole machine is well designed, of powerful construction, and excellent workmanship. It weighs 10,400 kilogrammes, or about 10 tons 2 cwt.

We have now to speak of two smaller exhibits of the firm whose tools we are noticing, the first being a portable crank-pin turning machine, and the second an ingenious little tool for cutting elliptical holes. Of the former tool an engraving is given on Plate CXCVI., Fig. 4. The working of this apparatus will be easily understood from the engraving, and we need only briefly state that the whole tool is fixed to the boss of the wheel by four bolts with one common counter or back plate. The frame carrying the pinion and the pulley, of 12 in. in diameter, thus remains fixed, whilst the inside frame or tool holder revolves with the spur wheel, which has 79 teeth of $\frac{5}{8}$ in. pitch. The tool holder is fixed to a screw, and the travel of the cut is effected by a small wheel, fastened at the end of the screw, striking at each revolution against a pin fixed to the main frame, whence it revolves for one or two teeth, and thus turning the screw, produces the travel of the cutting tool.

The elliptical hole or groove cutting apparatus just referred to is illustrated on Plate CXCV., Figs. 4 to 7. It is chiefly used for cutting the grooves for copper-wire joints on the surfaces of oval manhole covers or on the seats of oval domes. The apparatus consists, as will be seen from the engraving, of a plate *a*, which is fastened by means of the four screws *b* to the dome seat *c*, and upon which the plate *d* moves in the direction of the larger axis of the ellipse, whilst the plate *e* travels in the direction of the smaller axis. Both the plates *d* and *e* are guided by the pins *f f*, screwed into the lower plate *a*, but the plate *d* is provided with the bolt *g*, which carries the axis *h* with the bevel pinion *i*. The cruciform slide *k*, with the bevel wheel *l*, and the tool box *m*, move round this bolt *g*, whilst the ring *n* turns in the plate *e*, and is connected by means of three screws *s s s* with the slide *k* in such a

manner that the distance between the two centres *v* and *w* can be altered within certain limits dependent upon the slots at the screws *s s s*. When the apparatus is actuated by turning the crank *p* the slide *k* and the ring *n* travel round the two centres *v* and *w*, whilst the latter pass in the direction of the axis of the ellipse backwards and forwards, whence the tool *x* describes an ellipse, half the difference of the axes of which is determined by the distance between the centres *v* and *w*. If this distance be reduced to zero, the tool *x* will describe a circle.

The example of the apparatus above described, exhibited by the Sächsische Maschinen Fabrik, was well executed, and will be found a useful tool for many engineering works.

The remaining tools at the stand of which we are speaking do not require special notice here; but we may add that the whole collection showed very good designing and workmanship.

One of the best collections of tools in the German section was undoubtedly that of Messrs. Heilman, Ducommun, and Steinlen, of Mulhouse, who showed a very large number of machines, all admirably finished. The collection did not include any very heavy tools, but consisted principally of the smaller class of machines for light work. Thus there were some excellent milling machines, one having a vertical spindle for carrying the milling cutter, and having a bed provided with adjustable centres between which the work to be operated upon could be mounted. One of these centres was fitted to a spindle provided with dividing gear, so that the work mounted between the centres could be accurately turned through any desired angle. The collection also included a neat machine for cutting milling cutters, some excellent screw-making machines and stud lathes resembling those made by Messrs. Smith and Coventry in this country, and a large number of lathes, punching, and shearing machines, and other ordinary tools, all of exceedingly good design and workmanship.

Near to the exhibits already spoken of the Chemnitzer Werkzeugmaschinen Fabrik (formerly Joh. Zimmerman), occupied a large space with their evry numerous exhibits. Several of these we shall also have to describe in detail, and we may begin with the horizontal boring and milling machine illustrated on Plate CXCV., Figs. 8 and 9. This machine appears to be of very useful type on account of its various applications, and its arrangement will be readily understood from the views given. The vertical adjustment of the table enables the article to be bored out to be easily fixed, and the machine is especially suitable for the boring out of all kinds of bearings, hangers, brackets, &c., by means of a boring bar. The machine is also convenient for the boring and turning of wheels, pulleys, &c., on the face plate, as well as for the cutting of keyways in shafts. For this latter purpose the shaft is placed across the table and an ordinary cutter is fixed in the spindle. The traverse of the table against the motion of the cutter enables wide and deep grooves to be cut with one traverse of the shaft.

Next we may notice the plate bending rolls, illustrated on Plate CXCVII., Figs 1 and 2. The rolls are 2·25 metres (88·58 in.) in length, and 250 mm. (9·84 in.) in diameter. The pulleys are arranged so as to drive, through double gear, both backwards and forwards. There is a very neat arrangement for raising and lowering the top roll. A hand wheel at one end of the machine communicates motion through a pair of bevel wheels to a horizontal spindle traversing the whole length of the rolls. This spindle has two worms on it which gives motion to worm wheels (one of which is seen in the end view) on the outside of two columns lying right underneath the end gudgeons of the roller. The rotation of these worm wheels raises the roller (which is shown in the engraving in its lowest possible position) by means of internal screws. The machine is simply and strongly constructed, and its workmanship was first class; it is intended to bend plates up to $\frac{3}{4}$ in. in thickness.

Amongst the exhibits of this firm, which we may specially notice here, was a fine plate-edge planing machine, intended for heavy work, and having two tool holders, which in the machine, as exhibited, carried two tools cutting in opposite directions, one tool planing the edge of the plate and the other taking a bevel cut. Another fine machine was for cutting large spur and

bevel wheels, the tool-holder in this machine oscillating on a centre, and the form of tooth cut being determined by a contact piece, which is carried by a radial arm from the tool box, and which, as the feed takes place, is moved over a copy or template of the tooth which it is required to produce. This machine is illustrated on Plate CXCVII., Fig. 4. The same firm also showed another wheel cutting and dividing machine, which was a direct copy of the machine for these purposes made by Sir Joseph Whitworth. This machine which is illustrated on Plate CXVII., Fig. 5, is adapted for cutting wood patterns, as well as for the softer metals, such as brass, zince, tin, &c., in which case a cutting tooth is used, whilst the cutting and shaping of cast and wrought-iron wheels is effected by means of a rose cutter. Both these tools are provided with the machine, which is capable of cutting all classes of spur, bevel, and worm wheels, up to 3 ft. 9 in. in diameter for iron, and 5 ft. 6 in. for wood and of widths varying from $\frac{3}{8}$ in. to 10 in.

The motion is transferred from the overhead gear by means of the two small vertical pulleys to the horizontal rope pulley on the machine, this pulley driving by means of spur wheels, the spindle carrying the cutter. This spindle is fixed to a slide, which is moved horizontally, but only in one direction, by means of the gearing in connexion with a screw spindle, whilst the slide has to be moved back by hand after the wheels have been put out of gear.

The wheel to be cut or divided, is fastened to the disc shown in the engraving; on the shaft of this disc is mounted at the other end the large spur wheel, which gears into an endless screw sliding upon a shaft running alongside the bed of the machine. One of the handles shown on the right-hand side of the machine is used for turning this shaft, and by differently arranging the change wheels on the left-hand side of the machine, any desired pitch may be obtained. The second handle on the right-hand side of the machine is used for working a screw by means of which the whole tool-holder can be moved forward and backward during the operation of cutting screw wheels.

There was also in the same collection a kind of special lathe for bell-mouthing, and for reducing the ends of locomotive tubes, or of pieces to be brazed on such tubes, the object of the bell-mouthing and reducing being to fit the tube and lengthening piece together, so that a neat job may be made of the brazing.

This machine, which we illustrate on Plate CXCVII., Fig. 3, is extremely simple, and of a very useful character; it consists of an ordinary lathe bed 2 ft. $6\frac{1}{2}$ in. high and 11 ft. 7 in. in length, upon which are fixed the headstock and the sliding rest, with two brackets for the support of the tube. Three different manipulations have to be performed on the machine, namely, the cutting off of the burnt part of the tubes, the outside tapering of one tube end, and the inside tapering of another new end, so that if the latter is put into the former, the joint will correspond outside and inside with the other parts of the tube. The headstock is provided with an ordinary spindle carrying a loose and a fixed pulley, and extending to the point of the headstock where the different tools for the three manipulations are screwed on in the same manner as on an ordinary lathe. For the purpose of cutting the tube a circular saw 11 in. in diameter is fixed to the spindle, and the tube being supported by the brackets, which are movable and of sufficient width, is moved by hand towards the saw, which passes through a slot in the bracket. For the two other manipulations of cutting the outside and inside ends of the tubes, the latter are placed on the sliding rest, which is fixed on the bed, but which has two motions by means of screws, one at right angles to and the other parallel to the centre line of the bed. By the rectangular slide the tubes are fixed exactly in the centre and the height of the cutting tool, and are then moved over or inside the knife-holder. The parallel slide is moved by a handle and a pair of conical wheels connected with the spindle, an arrangement of levers being provided to produce a uniform forward motion of the tube.

Another handy little tool exhibited by this firm was a portable machine for tyre drilling; this little machine being made so that it can be securely fixed in the V between the spokes of a wheel, and made to drill the tyre from the inside.

The construction of this little apparatus (which we illustrate on Plate CXCVII., Figs. 7 and 8), is so simple that but a brief description will be required. As will be seen, it consists of a light wrought-iron frame fixed between a pair of spokes of the wheel of which the tyre is to be drilled. At its outer end the frame abuts against the tyre, whilst at its inner end it is provided with a pair of set screws, which are tightened up against a wedge piece, inserted between the spokes, as shown. One of the side frames is provided with a boss traversed by a short shaft having a belt pulley at its outer end, while at its inner end this shaft is provided with a bevel wheel, which gears into another bevel wheel placed, as shown, on the spindle holding the drill, this spindle being capable of being fed downwards through it. Against the upper end of the drill spindle there bears a centre carried by a cross bar, and this bar is connected at its ends by a pair of forked links to another cross bar outside the tyre, this latter cross bar being furnished at its centre with a screw bearing against the outside of the tyre, as shown. By means of this screw the feed of the drill can be given. The machine is a handy one, and would be useful in many situations when the quantity of work to be done is not sufficient to warrant the employment of a more expensive fixed machine.

A machine for drilling locomotive fire-box stays, which has for some time been in use on the Continent, but which is, so far as we are aware, not used in England, was also shown at this stand. In this machine, which is illustrated on Plate CXCIX., Fig. 1, the stay bolt is held in the hollow headstock revolving at a speed of 380 revolutions per minute. The two discs being worked by an extra pulley, each revolves in the direction contrary to the revolution of the stay, and makes 680 revolutions, so that the real speed of drilling is at the rate of 1,060 revolutions per minute. The feed motion is given by weights attached to pinions working in a rack on the bed of the machine, and the drills must from time to time be pulled back by hand for the purpose of clearing. A constant jet of lubricating material is thrown upon the two drills, which at the close of the operation nearly meet at half the length of the stay. One machine of this kind will bore 70 to 80 stays per day.

The Chemnitzer Werzkeugmaschinen Fabrik (formerly J. Zimmermann), Chemnitz, also showed a small double-acting single standard steam hammer with a valve gear directly copied from that used by Messrs. Tannett, Walker, and Co., of Leeds. It was a very neat and handy little tool, and was arranged to be either hand-worked or self-acting, its maximum speed in the latter case being about 200 strokes a minute. The general shape of the hammer is clearly shown by Fig. 6 on Plate CXCVII.; and we may remark that the casting was remarkably clean and good, which is by no means always the case in the tools of even the best German makers. The piston-rod is of cast steel, the tup and piston being in one piece with it, and the lower cylinder cover and gland being on this account made in halves. The upper end of the piston rod is flattened to prevent it turning round. There are two valves only, an admission valve *a* and a distribution valve *b*. The former is controlled by the lever *c*, the rest of the gear being all in connexion with the distributing valve. When it is desired to make the hammer self-acting, the hand lever *d* is made fast by a screw in the position it at present occupies in the link *e*. This link is merely a slotted lever, free to vibrate a little when the lever *d* is moved, but not otherwise in connexion with the valve gear. The handle *g* is then turned until the sliding block in the end of the connecting rod *f* has been moved by the screw to the end of the link furthest away from the spindle *k*. The slotted link in which the block works is on the same spindle *k* with the rod *l*, and is compelled to vibrate along with the latter. The distribution valve is then worked automatically from the tup by the lever *l*, the distance *k f* (in the new position of *f*) being the length of the lever which works the valve through the connecting rods *f* and *h*, and the lever on the end of the valve spindle. When it is desired to work the hammer by hand, the screw securing *d* to *e* is loosed, so that the former can be moved at will, and *f* is screwed down by the handle *g* to the lower end of the slotted link. As *f* is then immediately between *k* and the valve, its motion (which is just as great angularly as before, being still derived from the tup), has no appreciable effect on the valve, which is now entirely under the control of the hand lever *d*.

The maximum stroke of this hammer is 280 mm. (11·02 in.), and the weight of its piston and rod, &c., 70 kilogrammes (154 lb.). It is worked at a pressure of 75 lb. per square inch, and, as has been already mentioned, it is double acting, the steam being admitted above the piston to intensify the blow. The gear for working the distribution valve is of steel. The weight of the whole machine is 2,200 kilos., or very nearly 44 cwt.

Besides the tools we have already mentioned the Chemnitzer Werkzeugmaschinen Fabrik showed some very good ordinary tools, including a good heavy planing machine provided with Smith and Coventry's tool holders. It is much to be regretted that in noticing the exhibits of this firm it is impossible to award them credit for the designs of their tools without running the risk of doing injustice to the original designers. We had hoped that, considering how generally this subject was commented upon at Paris in 1867, we should in 1873 have had to chronicle an improvement in this respect, but the collection of tools shown by this firm at Vienna included a most flagrant instance of appropriation without acknowledgment, in the shape of a copy of one of Mr. G. L. Scott's well-known wheel-moulding machines. The machine was a copy of one of Mr. Scott's early patterns, and was in many respects inferior to that he now makes; but this in no respect lessens the meanness of sending for exhibition a direct copy of a special and most valuable tool without the slightest acknowledgment of the just claims of the inventor. It is, however, some comfort to know that Mr. Zimmermann's conduct in this respect is properly appreciated, and was heartily condemned by the great majority of his fellow exhibitors at Vienna.

Mr. A. Lismann, of Munich, was the exhibitor of two small machines for bending and treating plates, these machines being of the types illustrated by us on Plate CXCVIII., Figs. 1 to 4, and Figs. 11 to 14. The first of these two machines is especially intended for the thinning of the edges of plates of any form and for bending and flanging them; also for rolling tubes, shafts, or any bodies, the forms of which are produced by a revolution around their axes. The main feature of the apparatus consists in the form of the rollers which rotate in opposite directions, and which are provided with screw threads as shown. These rollers are of course formed in various ways, according to the work they are intended for, and are set at various angles and in different positions for thinning and bending plates, rolling tubes, &c. Figs. 1, 2, 3, and 4, Plate CXCVIII., show a machine adapted for forming tubes, &c. In this machine the main shaft *a* gives a movement in similar directions to the three axles of the rollers *d d* by means of the internal gearing on the wheel *b*, Fig. 4, and the three pinions *c c c*. At the ends of the shafts *d d* the screw rollers are placed, the threads on these being formed according to the work to be done. The shafts are placed at equal distances apart, so as to form with each other an equilateral triangle, Fig. 2. Below the frame carrying the rollers is a sliding table *e*, which is moved to and fro by means of a screw; upon this carriage are fixed the adjustable sliding brackets *f* and *g*, between which a pattern or model to which the object to be rolled is to be formed, is attached. On the other side is a third bracket *i*, also adjustable, and used to support the body that has to be rolled into shape. This bracket is provided with a spring or weight, which always presses against the metal being shaped, so as to keep it in contact with the rollers. The regulating rollers *k k* mounted on the shaft *d*, revolve always upon the surface of the pattern, and thus measure the exact distance apart of the screw rollers, which, therefore, bear only upon the metal acted upon as the guide rollers permit. In rolling a tube a mandril is mounted between the brackets *i g*, and the plate is wrapped by the rollers around the mandril; or, in rolling a solid body, the form is regulated by the action of the rollers, which, bearing upon the pattern, vary according to the relative positions of the rollers.

Figs. 5 to 10, Plate CXCVIII., show the construction of a machine for stretching, bending, or flanging plates. This machine was not itself exhibited at Vienna, but illustrations of it were shown. In this arrangement the screwed rollers are driven in opposite directions by gearing as represented. The bearings of the upper axle are carried by a frame, which turns around a pin fastened to the top of the plummer block of the lower shaft (Figs. 5 and 10).

The distance between the two axles or rollers may be regulated by the screw gear either on the front or back standard of the frame; the adjustment on the rear pillar is chiefly used for placing the two shafts parallel to each other. If a circular plate is operated on, it is supported at the centre by a frame *a*, which can be moved to and fro by a screw working in the slide *b*, which is connected with the crossbar *c*, carried in the bearings *d e*; these bearings are movable horizontally by means of a rack and pinion.

If the plate has to be stretched around the edge, it is fastened in the frame *a*, and adjusted with relation to the rollers of the slide *b*. Pressure is then put upon the rollers, and the edge of the plate is extended. In order to remove the marks made upon the plate by the threads of the rollers, the operation is resumed and the lines of contact are then made to cross each other and the surface becomes smooth. To bend the side of a plate the edge is gradually brought between the rollers, and the carriage on which it is supported is raised.

In rolling flanges, on a cylinder, for example, the cross-bar *c*, shown in Figs. 5 to 7, is removed, and the part Figs. 8 and 9 is substituted. A pressure roller *f* is fastened to a vertical shaft on the slide *b*, which carries instead of the frame *a*, a movable head with a face-plate provided with sliding blocks that are pressed against the revolving cylinder by means of a right and left handed screw. The edge of the cylinder to be flanged is then brought between the screw rollers and the position of the carriage on which the cylinder is mounted is gradually adjusted until the flanging is completed.

The other machine shown at Vienna by Mr. Lismann is, as we have said, illustrated on Plate CXCVIII., Figs. 11 to 14. In this arrangement the vertical axles are provided with rollers of different diameters, which, by means of bevel gearing, are driven at the same circumferential velocity. The plate to be bent is fastened to a template, shaped according to the form desired, but which is as much smaller as the constant distance of the periphery from the inner edge of the bent plate, which in the engraving is equal to the diameter of the small roller plus the diameter of the roller *g*. The template with the plate to be bent has a universal movement by means of the balls placed upon the table *t*, to which is fastened the friction roller *g*, which acts as a guide for the template *k*. The whole table, with the template, the friction roller, and spindle for fastening the plate to be bent, is movable around the centre *x*; for this purpose, and in order to allow of large-sized plates being bent, the segmental slides *d* and *e* are connected with the two sides of the table. These slides carry the horizontal and vertical reversing pressure roller *f*, which prevents the plate from buckling during the operation of bending.

The circular motion of the table is effected from the main shaft by means of the bevel and reversing gear *i k l*. Transferring motion by means of a worm wheel and screw to the horizontal shaft *m*, the pinion fastened on this latter shaft gears into the segmental racks *n n*, which are connected with the table and impart a circular motion. In order to prevent lateral oscillation of the table the racks *n n* move in guides. The plate to be bent is fastened to the template *k*, the latter is brought up to the rollers until they catch a corner of the plate previously bent; the rollers revolving draw plate and template forward, and the former is bent to the figure, while that of the latter is transferred to the plate. With the arrangement shown in Fig. 4 circular plates may be bent, and by a slight modification flanges may be rolled upon cylinders.

Close to Mr. Lismann's exhibits, A. Estever, of Altotting, Bavaria, showed a machine for planing stone columns, including those having twisted flutes. In the case of these latter the mass of stone is mounted between centres on the table of the machine, and as the table moves forward the block is moved by the action upon it of a slide trasversing a diagonal bar, the arrangement being somewhat similar to that of a rifling machine. The tool apparently turned out very good work, but it was rather rough, and the wearing surfaces appeared to be insufficiently protected from the dust produced by the cutting of the stone. Another small exhibitor was Mr. Limbach, of Chemnitz, who showed a small lathe with a gap and bridge-piece fixed over the gap. The work was good, but there is nothing in the design requiring special notice

here. Near the exhibits last mentioned we noticed another most flagrant instance of appropriation of designs without acknowledgment, the "appropriator," to use a mild term, being Ludwig Loewe, of Berlin (who also affixed to his exhibits the title of the Loewe Sewing Machine Manufacturing Company, Berlin), and the victims Messrs. Pratt and Whitney, of Providence, U.S., of whose admirable machine tools we have already had occasion to speak. This Ludwig Loewe showed a set of machines for manufacturing the details of sewing machines which were simply absolute copies of Messrs. Pratt and Whitney's, as far as appearances go, although whether the workmanship was equally true we had no means of judging. Of course, under the present circumstances, Messrs. Pratt and Whitney have no legal remedy for this state of things; but we certainly think that it shows a most careless performance of their duty on the part of the jury when we actually found Ludwig Loewe's exhibits awarded a "verdienst medal." We consider it most scandalous that an award of merit should be made to a man who not only appropriates designs wholesale, but who actually has the impudence to send his copies to an exhibition like that at Vienna to compete with the products of the firm whose ideas he has stolen, without the slightest acknowledgment.

F. X. Honer, of the Werkzeugmaschinen Fabrik Ravensburg, Wurtemburg, showed several ordinary tools of substantial types, including a drill having two spindles, one in front, and two others behind, the main standard. This pattern of drilling machine appears to be a favourite one with many of the Continental makers, and it is one which is undoubtedly convenient in many respects. At the stand of L. A. Riedinger, of Augsburg, the speciality was a good wheel-cutting machine (E. D. Leupolt's patent), the peculiarities of which we could scarcely explain clearly here. In an adjacent stand, Mr. Carl Thomas, of Dresden, showed a good heavy screwing and tapping machine—apparently especially intended for preparing the nuts and screws for screw couplings—work which it does well.

Close by, too, Messrs. J. G. Schone and Son, of Leipzig, showed a number of tools of good workmanship and creditable design. One of these—a planing machine—we illustrate on Plate CXCIX., Fig. 2. The machine embodies nothing specially new in its construction, but is very strongly and simply made, and ought to be an excellent working tool. It is intended for planing both horizontal, vertical, and bevelled surfaces. It will be seen that it is provided with two tool boxes; of these the one to the right is a fixed box of the ordinary construction, while the one to the left consists of a couple of clamps, either of which can be moved sideways at pleasure, the object of the latter is to allow the tool to be placed in the rest at an angle, which is often more convenient for, for instance, undercut surfaces. The machine is made self-acting throughout, and the tool slide, as usual, can be set at any angle. The width between the standards is 850 mm. (33·46 in.), and the maximum height available for work is the same distance. The length of the moving bed is 1,700 mm. or 5 ft. 7 in.

Two other exhibits of Messrs. J. G. Schone and Son are illustrated on Plate CXCVIII., these being a nut shaping and a slotting machine. The machine shown by Fig. 15 is for shaping nuts of sizes up to $4\frac{3}{4}$ in. across the sides and $3\frac{1}{2}$ in thick, and it is fitted with two tools for acting on two sides of the nut simultaneously, as shown. The crank spindle is run at 120 revolutions per minute. In this country Messrs. Sharp, Stewart, and Co., and other makers, have produced machines of a similar type, and very handy tools they are. Figs. 16 and 17 of Plate CXCVIII. show a strong slotting machine of 4 in. stroke, capable of taking in articles up to 28 in. in diameter. It is provided with a cross slide, and is fitted with self-acting gear for either a rectilinear or circular feed. The design of both the machines illustrated is, as will be seen, very neat and substantial, and the workmanship was also good.

We now come to the stand of Messrs. Wagner and Co., of Dortmund, who showed some excellent tools, the principal ones being a rail-ending machine, a rail sawing machine, a heavy bloom shears, and an ingeniously arranged rail-drilling machine. There was also a substantial bending or straightening machine for rails and light girders. These exhibits we shall describe in the order in which we have mentioned them. The rail-ending machine is illus-

trated on Plate CXCIX., Fig 3. The end of the rail is placed between jaws, as shown in the end view, these being removable at will, so that jaws to suit any shape of rail can be easily placed in the machine. The rail is held tightly and firmly in place by screwing down the end of the lever which crosses the upper jaw, but, at the same time, as this lever is weighted at its free end, a man can lift it without any trouble (when the screw is released) to let the rail be taken away. The cutting apparatus consists of four tools placed radially in a revolving disc fixed on the main mandril of the machine. The centre of this disc is somewhat higher than the upper face of the rail, so that the cutters can reach every part of it fairly, although, of course, not with equal velocities. A hand wheel near the front of the machine (on the left-hand side of the engraving) gives motion to a countershaft which, by means of spur gearing at its further end, can give separate and (by an internal screw) forward motion to the mandril, and so feed the tools up against their work. This machine is driven by the pulleys A on a countershaft through the intervention of spur gearing. The spur wheel, however, is not fixed to the mandril itself, but on an exterior sheath which, when it revolves, causes the mandril to revolve with it, but is prevented from sharing the feed motion of the latter above described. By means of an eccentric on this sheath, working a ratchet wheel on the same shaft as the hand wheel, the feed motion can be made self-acting at will, and the tools can also be withdrawn by a self-acting motion.

Messrs. Wagner and Co.'s rail-sawing machine—which is intended for cutting the ends of rails cold—is illustrated on Plate CXCIX., Fig. 4. It is so clearly shown in the elevation and plan there given that a few words of explanation will suffice to make it intelligible. The belt pulleys drive the saw at a comparatively slow speed through the double, or more correctly triple, gearing. The rail slide rest is entirely separate from the bedplate of the machine, but both are bolted on to a planed cast-iron bedplate. Spur and worm gearing is arranged to make the feed of the rail against the saw self-acting, but a wheel is also provided to feed by hand when necessary. The return motion of the bed can only be worked by hand. The whole machine is strongly constructed, and has large bearing surfaces; it seems well adapted to the purpose for which it is intended.

Messrs. Wagner and Co. also, as we have said, exhibited at Vienna the large double shearing machine for blooms and other heavy work, which is illustrated on Plate CC., Figs. 3 and 4. The machine weighs about 18 tons, every part being of the heaviest, and it can cut bars up to 65 mm. (2·56 in.) square. It is worked by its own engine, which is vertical, and has a cylinder about 9 in. diameter, and a pinion on the crank shaft gears direct into a large wheel on the cam shaft. There is nothing remarkable about the engine except the extraordinary form given to the shaft, for what reason we were unable to find out. Both the cams and the shear levers are of cast iron, very massive in structure, and the under sides of the levers and heads of the cams are lined with steel. The bearings of the shafts all run in brasses, and the more important ones are made adjustable both ways. A guard is provided in front of each pair of shears (see Fig. 4) to prevent the bloom or bar being pulled up or thrown over. An adjustable stop is also arranged, working on a rod behind each pair of shears (see Fig. 3), so that any number of bars can be cut off to the same length. The flywheel is about 9 ft. (English) diameter. It will be seen from the engravings that the whole machine rests on a heavy bedplate, which has cast with it the front bearings for the shear gudgeons. The other bearings are all carried in brackets cast separately, and bolted to the bedplate. In the engravings Fig. 3 is a side, and Fig. 4 a front elevation of the machine, in which the necessary foundations, as well as the machine itself, are clearly shown.

Next comes Messrs. Wagner's rail drilling machine, illustrated on Plate CC., Figs. 1 and 2, and intended for drilling the holes in rails for the reception of the fishbolts. The engravings show a side and an end elevation of the machine, and from the former it will be seen that the motion is transferred from the pulleys by a pinion gearing into a spur wheel, to the central shaft carrying one of the boring tools; this shaft and two others, one on each side, which carry the second and third drills, run in bearings in a slide moving across another

slide, which travels on a heavy bedplate or frame, as shown in the engravings. To the front of this bed is attached a table upon which the rail is fixed. Before describing the manner in which the double motion, necessary to produce the oval shape of the holes and to feed the boring tools, has been arranged, we should state that the three boring spindles, being very close together, it became impossible to connect them by direct gearing. In order to avoid this difficulty two intermediate toothed wheels are supported by links, which are hung obliquely from the central and one of the outer axes; pinions fixed on these shafts gear into the intermediate wheels, and transfer the motion in the same direction, and at the same speed, from the central shaft to the two outer ones. To the left-hand side of the frame is attached a bracket, which carries at the lower part a shaft with a screw gearing into a worm wheel; the screw shaft has at one end a pulley, to which motion is transferred from a small pulley placed on the main driving shaft. The worm wheel transfers the motion to a double bevel gearing; the larger and horizontal bevel wheel is provided at the top with a slot, into which is fixed an adjustable pin, passing through an eye at one end of a rod, the other end of which is connected with the transverse slide. According to the position of the pin in the slot the slide will have a greater or less travel, and this motion produces the oval shape of the holes in the rail. The inner bevel wheel is fastened to a shaft passing through the bed, and carrying at the other end a second pinion gearing into a spur wheel. This spur wheel runs loose on a shaft, passing through the transverse slide, and imparts a slowly advancing motion by means of a rack and pinion slide, when it is locked upon the shaft by means of the locking gear and hand wheel. The spur wheel is made narrower than the pinion, in order to follow the motions of the transverse slide without getting out of gear; and by disconnecting the spur and hand wheels the upper slide can be drawn back by means of the latter, after the holes have been drilled, without interfering with the gearing. The frame of this machine is used as a storing place for tools, and is for this purpose provided with a door at the side.

The only other exhibit of Messrs. Wagner and Co.'s remaining to be described is the machine for straightening rails or light girders, illustrated on Plate CC., Figs. 5 and 6. As will be seen from the engravings, the machine consists of a strong bedplate 7 ft. 9 in. long, 5 ft. 1 in. wide, and 1 ft. 7 in. high, on which are cast at the front side two strong brackets, each having a dovetail groove, in which slides a wedge-like vertical rest for the support of the rails to be bent or straightened; these vertical bearing pieces are each provided with a handle, and are moved by hand. The bedplate has cast on its top a cylinder with four brackets, upon which are placed the two uprights carrying the driving shaft; whilst the pressing ram passes through the cylinder. This ram is moved forwards and backwards by a single-threaded screw 6 in. diameter and $1\frac{1}{4}$ in. pitch, arranged as shown. The outside width of the machine over the uprights is 4 ft. $8\frac{1}{2}$ in., whilst the height from centre of driving shaft to top of bedplate is 3 ft. 5 in. The driving shaft carries two pulleys 2 ft. 6 in. diameter and 8 in. in width, which run loose on the shaft, but which can be made to drive the latter by means of a hand lever, which shifts friction cones keyed to the driving shaft. One pulley is driven by an open, and the other by a crossed belt, and the right or left-hand motion of the screw can thus be produced. The motion of the shaft is transferred to the screw by a spur wheel of $2\frac{5}{8}$ in. pitch and $5\frac{1}{2}$ in. width, the pinion having 13 teeth and the wheel 66 teeth. The diameter of the press ram is 1 ft. $5\frac{1}{2}$ in., and the greatest stroke 14 in. The machine is of a good substantial pattern, and was, like all Messrs. Wagner's exhibits, very well made.

In the same group as Messrs. Wagner and Co., were the Werkzeugmaschinen Fabrik "Saxonia" (formerly Constantin Pfaff), of Chemnitz, who showed some tools distinguished by their exceedingly neat and good design. A fair idea of these tools can only be conveyed by illustrations, and we give on Plate CXCIX., Figs. 5 and 6, engravings of a double shaping machine, and on Plate CC., Fig 7, a view of a slot-drilling machine, which may serve as examples. The former machine consists of a strong and well-designed bed 8 ft. $8\frac{1}{4}$ in. long, upon which the two rams, which are independent of each

other, move. Each of these is really a distinct shaping machine, and receives its motion from a separate set of four-speeded pulleys, so that either may be worked independently. The motion is transferred from the pulleys by means of a double gearing to the crank disc; a crank pin on this disc works in a slotted lever, of which the lower end works on a fixe centre, whilst the upper one is connected by means of a rod with the ram, which runs in the cross slide on the common bed of the machine. The ram carries at the front end the adjustable tool-holder, whilst sliding tables with grooves are fixed in front of the bed, for the reception of the work which is to be planed or shaped. These tables have both a vertical and horizontal movement worked by hand. The adoption of the arrangement just described produces a rapid return motion of the slide with the tool-holder. For the purpose of moving the slides in a direction parallel to the axis of the bed, the inner side of the main spur wheel is provided with an eccentric groove, in which runs a pin connected in the usual manner by a combination of levers with a ratchet wheel fixed upon the screw at the centre of the bed. The arrangement adopted for effecting the vertical motion of the tool-holder, which is regulated by a screw spindle, is as follows: The top of this spindle carries a ratchet wheel, the detent of which is worked by a rod guided in a vertical bracket fastened to the slide with the tool-holder. If this slide, therefore, is moved backwards and forwards, the vertical bracket must follow this motion, and the rod in connexion with the detent being provided with adjustable blocks, the latter, when the bracket strikes against them, carry the rod with them, and thus cause the detent to turn the ratchet wheel for a certain distance, transferring the motion to the screw spindle in connexion with the ratchet which raises or lowers the tool-holder.

The length of the bed is as already stated 8 ft. $8\frac{1}{4}$ in., and the maximum stroke is 500 millimetres ($19\frac{11}{16}$ in.). The machine is of good proportions, and the workmanship leaves nothing to be desired. The frame and tables are very strong, and showed excellent castings.

The slot-drilling machine by the same makers is, as we have said, illustrated on Plate CC., Fig. 7. This machine consists of the frame or bed, with the table adjustable both vertically and horizontally at the front, and the sliding frame with the boring spindle on the top. Motion is transferred from the shafting to a four-step pulley, carried on an axle by the sliding frame, the boring spindle being driven by bevel wheels, as shown, whilst the raising or lowering of the spindle by means of the screw at the top is effected either by hand, or by the machine itself, for which purpose the shaft carrying the hand wheel is connected by means of bevel wheels with a ratchet motion. The shaft for the step pulleys carries outside the slide frame a smaller set of step pulleys, from which the motion is transferred to a step pulley fixed to a shaft on the bed or lower frame; this shaft carries a screw working into a worm, above which is fixed, upon a common shaft, a spur wheel gearing into another spur wheel, cast together with a disc, which has a radial slot at the top. A pin sliding in this slot, but which may be fixed at any position, is connected by means of a rod with the slide frame, which is thus moved backwards and forwards, according to the stroke given, by the position of the pin in the slot, whilst the boring spindle rotates independently. The second spur wheel, with the slotted disc at the top, has attached to it below a cylindrical extension, which is provided with a cam groove, from which the gear for feeding down the spindle is worked in the ordinary way. The machine drills slots or grooves 1 in. wide and $7\frac{7}{8}$ in. long. The table which, as has been stated already, is adjustable both vertically and horizontally, has a width of 15 in. and a length of 2 ft., whilst the bed or under-frame is 3 ft. 4 in. high, 1 ft. 5 in. wide, and 2 ft. 4 in. long. The workmanship of the machine exhibited at Vienna was very good, and especially the castings were well done. We may mention here that the Werkzeugmaschinen-Fabrik Saxonia was founded in 1838 by M. Constantin Pfaff, of Chemnitz, in the kingdom of Saxony, and that only machine tools are built there, 256 men being employed on this work at the time of the Exhibition.

Immediately adjoining the exhibits last noticed we found two new tools shown by the Deutsche Werkzeugmaschinen Fabrik (formerly Sondermann

and Stier), Chemnitz. One of these is a machine for planing the edges of the spokes of locomotive wheels, and is illustrated on Plate CC., Figs. 8 and 9. In this machine the wheel to be operated upon is mounted on a table having a circular motion and a transverse motion along the bed, these motions, however, not being self-acting. The tool-holder is carried by a reciprocating ram similar to that of an ordinary shaping machine, but instead of this ram moving in a horizontal direction only, it works in guides formed on a plate which can be adjusted at different angles, so that the tool is made to take its cut in a direction corresponding to the desired taper of the wheel spokes. The arrangement will be readily understood from our illustrations.

The tool-holder at the end of the ram is adjustable vertically, and it is also provided with a toothed arc actuated by a worm, and so arranged that the point of the tool can be made to traverse on the arc of a circle, convex upwards, this traverse being self-acting. In this way the desired rounded form can be given to the edges of the spokes. The motion is given to the ram by a crank of adjustable throw in the ordinary way, and it will be noticed that the carriage or head on which the ram is mounted is capable of being traversed along its bed by self-acting gear, the machine being thus made available for a variety of work besides that of spoke-edge planing. This machine is in fact a very useful one for a locomotive shop where it is desired to turn out highly finished wheels, and the example shown at Vienna was well built and of very good design generally.

The other machine exhibited by the same firm is for shaping the edges of the crank bosses of locomotive driving wheels, and is illustrated on Plate CCI., Figs. 10 and 11. The machine consists, as will be seen, of a strong hollow framing, similar to that of a drilling machine, this framing carrying a stiff hollow spindle, provided at its lower end with a radial arm carrying a slide rest on which a tool-holder is mounted. Motion is given to the spindle by a worm gearing into a worm wheel, as shown, and the spindle of the worm is provided with two sets of fast and loose pulleys of different diameters, one set being driven by an open, and the other by a crossed belt. This arrangement enables a slow motion to be given to the main spindle in one direction, and a quick return motion in the other direction, according to which of the two belts is on the corresponding fast pulley.

The shifting of the belts from the fast to the loose pulleys is effected as follows: projecting from the upper side of the worm wheel, which we have mentioned as giving motion to the main spindle, is a rim having turned in its periphery a dovetailed groove. In this groove slide two stops, as shown, these stops being capable of being fixed at any desired points on the circumference. As the main spindle revolves, the one or the other of these stops is brought into contact with an arm projecting from a short upright shaft carrying a bevel wheel at its upper end, this wheel gearing into a similar wheel fixed on the horizontal spindle which carries the lever actuating the belt forks. The arrangement will be readily understood on reference to the side elevation, and it will be seen how—according as the stops are set—the main spindle will at different points in its rotation cause the shifting of the belt gear, and consequent reversal of the direction of motion of the spindle. The action is in fact exactly similar to that of a planing machine, except that the motion takes place in a circular instead of a rectilinear direction.

From the above explanation, it will be at once seen that the arm carried by the main spindle at its lower end can be made to vibrate through any desired arc, and, as the tool-holder is adjustable radially, the tool can be made to cut any circular convex or concave curve within the limits of radius permitted by the length of the arm. Thus, in finishing the crank boss of a locomotive engine wheel, a cut may first be taken from the point A to the point B in the diagram, Fig. 12, Plate CCI., and next a cut from the point C to that marked D, while finally the boss would be finished by taking concave cuts between the points B and C, and A and D respectively. The main spindle is adjustable vertically by hand gear, as shown, while the work to be operated upon is carried by a table having longitudinal and circular motions. The machine shown at Vienna was well built, and the details were, for the

most part, well designed. We believe, however, that the framing and some other parts might be made still heavier with advantage, and, in particular, the cross slide for the table appears to us to be too light. We should ourselves have preferred making the bed itself wider. It is evident that the machine we have described is applicable to many other purposes besides that of shaping crank bosses, and we believe that it will be found a very useful one in many works.

Next we found Hermann Ulbricht of Chemnitz showing some ordinary lathes requiring no special notice, and near him Ludwig Muller, of Krauzegg, near Immenstatt, Bavaria, exhibiting some small foot lathes fitted with an arrangement for screw cutting by giving a longitudinal feed to the main spindle. Thus the headstock carries at its outer end a slide provided with a stud, on which is mounted a kind of disc having semicircular recesses formed around its periphery. These recesses are tapped with different threads, and the disc can be turned round so as to bring any one of them into contact with a ferrule screwed to the same thread, and fixed on the projecting end of the lathe spindle. The slide gives the means of adjusting the distance between the centres of the spindle and disc, and the notches thus serve as a series of half nuts, and feed the spindle forward longitudinally in its bearings at a rate corresponding with the pitch of the screwed ferrule placed upon it, and any article carried by the spindle may thus have a corresponding thread cut on it by a fixed tool. Modifications of this arrangement are shown in some foot lathes exhibited by other makers.

Alfred Kühn, of Gera, showed a small lathe, drilling and boring machine, of fair workmanship, but ordinary pattern, of which we need not speak further here, while Messrs. Nestler and Breitfeld, of Erla, near Schwarzenberg, Saxony, showed a neat nut-tapping and screwing machine, in which the various tapping and screwing operations are performed by means of a series of vertical spindles arranged around a central standard. This machine, which is, as shown in our illustrations on Plate CCI., Figs. 1 to 9, of the vertical type, allows four screws or nuts to be cut at the same time, and is now being built by the manufacturers in two sizes; it is said to work well, and, although it is stated to do the work of four machines combined, requires less space than one screw-cutting machine of the ordinary type. The machine consists, as will be seen from the general view, of three parts, the driving gear, the fixed under frame, and the movable top frame. The driving gear is of the ordinary class usually adopted for lathes, and transfers its motion by means of two bevel wheels of $1\frac{1}{2}$ in. pitch, with 28 and 40 teeth respectively, to the central upright shaft B, which passes through the fixed under frame, and round which is moved the top frame, as shown in Fig. 1, Plate CCI. The fixed under frame is of a light open design, and is provided at the top with a dish-like table A. The upright shaft B, $2\frac{3}{8}$ in. in diameter, carries, as shown, a spur wheel of $1\frac{1}{4}$ in. pitch, with 18 teeth, and 12 in. in depth, this wheel gearing into four other spur wheels, each having 30 teeth, and each fastened to a spindle C, which is guided by two cast-iron discs. These cast-iron discs are connected with each other, and with a third disc underneath, by means of four wrought-iron columns, thus forming together the top frame moving round the vertical shaft B. The screws or bolts to be cut are fastened, as shown in Figs. 1 and 4, to the spindles C, which can be moved up and down by means of levers and counterweight, without bringing the spur wheels out of gear. The fastenings for the various kinds of bolts to the spindles will be easily understood from Figs. 1 and 4, in which F is a tightening bolt, and E are special pieces for each size and kind of bolt.

The screw dies are fastened in specially constructed boxes to the bottom disc of the movable frame, as shown in Fig. 1. Various arrangements and sizes of these boxes are represented by Figs. 2, 5, 6, 7, and 8, Plate CCI., from which it will be seen that, by simply turning a lever, the screw dies are removed from each other, thus allowing the bolt or screw with the threads cut to be taken out, and a new one put in its place. The screw taps are fastened to the spindles, in the same manner as the bolts, and the nuts to be cut are placed in hexagonal or square parts of the boxes on the bottom disc of the top frame. As these hexagonal or square parts of the boxes cannot, how-

ever, be opened or closed like the screw dies, the screw taps are reduced in diameter above the cutting part, whence, after the tap has passed through the nut, the former will fall through the latter into the dish-like table A. The lever D is used for fixing the top frame. The advantage of this screw cutting machine consists not only in the four-fold work, for which one man only is required, but also in the cutting of the threads by a single passing of the tap through the nut, or of the bolt through the dies. The machine exhibited at Vienna was one of the larger size, and can be used for bolts up to 1 in. diameter, and for nuts up to $1\frac{1}{2}$ in. diameter, of which latter 85 may be cut per hour, whilst of nuts, $\frac{3}{8}$ in. diameter, about 240 may be tapped per hour. The number of bolts screwed in the same time depends, of course, on the diameter of the bolt and the length of the threads. The machine which we have described has been patented by Mr. Breitfeld, of Messrs. Nestler and Breitfeld, and has found already an extended application on the continent, and the workmanship of the machine exhibited at Vienna showed that as far as execution is concerned, nothing is to be said against it.

P. O. Etterich, of Stuttgard, showed a boring machine, and also a similar small machine with two heads, in each of which the feed motion of the table is communicated through a telescopic rod fitted with two universal joints, an arrangement which has some points of convenience to recommend it. R. Kerzdörfer, of Ansbach, and Henrich and Son, of Hanau, were both exhibitors of a variety of small foot lathes fitted with elliptical chucks, &c., but not requiring special notice, while G. N. Justus, of Hamburg, also showed a couple of lathes, one of them fitted with a slide rest having a vertical slide, the arrangement being one apparently calculated to give far too elastic a support to the tool. The Berliner Eisengiesserei und Werkzeugmaschinen Fabrik (formerly Tietzsch & Co.), showed the neat wall drill illustrated by us on Plate CCI., Figs. 13 and 14. It is a simple and strong machine, and is clearly shown in the two views, of which Fig. 1 is a front and Fig. 2 a side elevation. The principal feature about it is that the whole table can be swung to one side on a pin (shown to the left in Fig. 1), and so be out of the way if it is wished to drill holes in any castings, &c., too large to be placed upon it, and of such a size that their own weight is enough to keep them steady while being drilled. The machine has single and double gear, the latter being thrown in or out of gear by means of an eccentric spindle with a square on its end, seen in Fig. 1. The feed can be worked by hand or made self-acting at discretion. The table can be raised and lowered by a wheel and rack in the usual way through a height of 18 in., and the feed of the tool is about 9 in. The same firm also exhibited an ordinary lathe and planing machine of somewhat rough workmanship, and presenting no point for notice here. Next we came to a lot of tools shown by the Werkzeugmaschinen Fabrik "Vulkan," (late William Bendorf), of Chemnitz, this collection including a wall drill with a table that folded back like Tietzsch's, and some other machines of good and substantial design, but presenting no special features.

Adjoining the exhibits last spoken of was the stand of Messrs. Gschwindt & Co., of Carlsruhe, who besides a quantity of wood-working machinery—of which it does not belong to the province of the present section to speak—showed some good small tools, as well as a drill with a table arranged to be turned aside when required, and a shaping machine with two tables, a removable bridge piece, spanning the space between the table, being provided for supporting the outer end of the central mandrel, on which circular or curved work can be mounted. The tables of this machine, as well as of some others, at Vienna, have vertical sides for the attachment of work as well as the ordinary horizontal top surfaces. Close by, the Maschinenbau Verein zu Chemnitz (formerly C. F. Schellenberg) showed some very fair ordinary tools requiring no special notice, while Messrs. Collett and Engelhard, of Offenbach-on-the-Maine, showed a plate edge planing machine and lathes, drills, shaping machines, &c., of which the designs were very good, although they embraced no special points of which we can speak here.

Amongst the exhibits of Messrs. Englerth and Cünzer, of Eschweiler-Aue, in the Machinery Hall, at Vienna, was the large punching and shearing

machine with steam engine attached, of which engravings are given on Plate CCVI., Figs. 5 and 6. As will be seen from the dimensions, the machine is adapted for heavy work, and it will cut sizes up to 2 in. by $2\frac{3}{4}$ in. The two sides of the machine are fitted with shears for plates and angle irons respectively the blades of the shears being in each case disposed at an angle of 45 deg. with the axis of the machine. The motion is given to the rams by connecting rods attached to crank pins formed on the end of the main shaft, loose blocks interposed between the ends of the connecting rods and the rams, and capable of being withdrawn by hand, constituting the stop motion.

The main shaft of the machine carries a spur wheel, which is geared into by a pinion on a counter shaft, this shaft carrying another spur wheel which is driven by a pinion on the crank shaft of the engine. The steam cylinder, which is bolted to the side of the machine, is 315 millimetres (12·4 in.) in diameter by 400 millimetres ($15\frac{3}{4}$ in.) stroke, while the whole arrangement is so clearly shown by the engravings that any further detailed description is unnecessary. We may add, however, that the makers of the machine we illustrate construct machines of a similar type of much larger sizes, the largest having a steam cylinder 3 ft. $1\frac{1}{4}$ in. in diameter with 3 ft. $7\frac{3}{4}$ in. stroke. The machine exhibited was substantially but very roughly built.

Steam hammers were shown in the German section by the Märkische Maschinenbau Anstalt (formerly Messrs. Kamp & Co.) of Witten-on-the-Ruhr, and Messrs. Gustav Brinkmann & Co., of Witten-on-the-Ruhr. The exhibit of the former firm was one of the most noticeable in the whole of the Machinery Hall, it being the 15-ton hammer, of which an engraving is given on Plate CCII. This hammer is an original design of the firm above named, which has been continually improved and simplified from practical results during the last seven or eight years, so that the hammer, as shown at Vienna, may be considered to fairly represent its makers' latest practice. It lies in the nature of a steam hammer that the greater the effect upon the pieces to be forged the greater are the destructive consequences with respect to itself. The proper acknowledgment of these consequences forms the principle upon which the design has been based, the problem being to counteract the effects in the most efficient manner. Referring to our illustrations, it will be seen that the standards of the hammer, carrying on the top the steam cylinder, are placed on a wrought-iron girder, supported by two wrought-iron columns, an arrangement which gives a certain elasticity to the whole construction, while at the same time it affords a larger space around the anvil of the hammer, and thus facilitates the free movements of the workmen. For most cases a span of 20 ft. from centre to centre of the column will be sufficient, whilst for the manufacture of very difficult forgings, a span of 25 ft. may be useful. The span in the 15-ton hammer, shown in the engraving, is 20 ft. 9 in.

The two heavy cast-iron standards offer a sufficient mass for counteracting the often heavy and destructive rebounding blows of the hammer. The wrought-iron bridge keeps these masses of iron firmly together, and prevents any giving way of the uprights. These latter are not only connected by a number of tightly-fitted bolts, but both uprights or standards are also fitted closely against the upper and lower cover plates of the girder, so that a movement would necessitate the shearing of all the rivets that pass through the plates.

The arrangement and working of the hammer is very simple, and will easily be understood from the engraving, but we may state that the piston and piston rod are made of best crucible cast steel, and that the hammer is single-acting, and is provided with double-seated equilibrium valves, which are worked by hand.

The weight of the tup of the hammer is, as stated above, 15 tons, the height of fall 8 ft. 3 in., the diameter of the cylinder 3 ft. $8\frac{1}{4}$ in. (1·098 m.), and the total weight of the hammer without block and anvil is 87,500 kilogrammes, or $87\frac{1}{2}$ tons, distributed in about the following manner: Each upright or standard, $14\frac{1}{2}$ tons; cylinder 5 tons; bedplate for cylinder at the top of uprights $5\frac{1}{2}$ tons; bedplates for foundation, 7 tons; each wrought-iron column, $2\frac{1}{2}$ tons; bridge, $6\frac{1}{2}$ tons; tup with piston and piston rod, 15 tons. Consider-

ing the insufficient lifting appliances that were available in the Machinery Hall of the Vienna Exhibition during the time of installation, the erection of this hammer was a work of considerable difficulty. The chief dimensions of the other hammers built by the Märkische Maschinenbau Anstalt on the same system are:

Weight of Tup. tons.	Height of Fall. ft. in.	Diameter of Cylinder. ft. in.
15	8 3	3 8¼
10	7 8⅛	3 1
7⅓	5 10	2 10
7½	5 2	2 10
5	5 2	2 6

The two last-named hammers are used for the forging of disc wheels, and work with steam acting above the piston, whilst the others act by their own weight only. All the hammers are provided with hand-worked valves.

Messrs. Gustav Brinkmann and Co., engineers, of Witten-on-the-Ruhr, Westphalia, are well known on the Continent for the manufacture of high-speed steam hammers, and it was, therefore, of interest to see some of their work exhibited at Vienna, namely, a double-acting hammer with single frame and a double-acting hammer with double frame. Both these hammers are used for tilting iron or steel, but the former has a constant stroke whilst that of the latter is variable. On Plate CCIII., Figs. 1 and 2, are given engravings showing front and back elevations of the double-acting and double standard hammer, the construction of which varies in several details from the steam hammers built in this country. As will be seen from the engravings, the anvil bed or stock is used as bedplate a for the hammer, an arrangement which is adopted generally by these manufacturers for high speed hammers, except in the case of tilting hammers for steel, the anvils of which are, without exception, made independent of the bedplate of the hammer. Another peculiarity of the construction, as seen from the engravings, is the mode of fastening the cylinder and of the guide bars to the standards, which is not effected as usual by means of bolts, but by wrought-iron rings shrunk over circular projections, one half of each of which is cast to the cylinder or guide bars respectively, whilst the other half forms part of the standards; when the latter and the cylinder and guide bars are respectively fitted together correctly, these projections form circular discs over which the wrought-iron rings are shrunk.

The hammer is worked by two levers, as shown in the front view, one of these levers enabling the admission of the steam to be regulated, whilst the other is used for altering the stroke and the force of the blow. The lever for regulating the admission of the steam can be fixed at any position, and its lower end is connected with a second lever, to which a rod for the working of the admission valve is attached. The one end of the lever for the alteration of the stroke can be fixed at various positions, by a spring and a notched segment, whilst the other end is fixed to a short shaft passing through the side bracket of the cylinder, as shown in the engravings. From the back view of the latter it will be seen that this short shaft, which is cranked on this side of the hammer, carries a double lever the two ends of which are connected with the valve rod and the valve gear respectively. The latter consists of a lever fastened to the ram, and a rod connecting this lever with one end of the double lever.

The admission of the steam into the cylinder is regulated by a piston valve, the position and travel of which depend upon the position of the cranked part of the shaft passing through the side bracket of the cylinder. It is evident, therefore, that any position of the lower end of the long lever (see front elevation) in the notched segment, must correspond with a certain position of the cranked part of the horizontal shaft, and thus also with a certain position and travel of the piston valve, upon which the stroke of the piston depends. The exhaust steam passes back again through the piston valve, and thence from the steam chest through a short tube (see back view) into the top side of the standard, from where it escapes into the exhaust pipe.

The weight of this hammer is 8 cwt., the cylinder has a diameter of 11 in., and the longest stroke is 18·5 in., allowing of forging iron pieces 6 in. to 7 in. high, and steel pieces 5 in. high. The average number of blows per minute is 200, and the whole hammer, with bedplate and anvil, weighs 8 tons; without the two latter 3 tons 17 cwt. The distance between the two standards at the bottom is 4 ft. 5 in., whilst the total height of the standards from the bedplate is 7 ft. The piston rod is made of crucible cast steel, has a diameter of 5½ in., and is formed in one piece with the piston and ram, whence the cover of the cylinder has to be made in two pieces. This hammer was shown working at the Exhibition, and the adjustment of the stroke and of the blow was proved to be very readily effected. We should mention, that the workmanship of the hammer is very creditable to the manufacturers, who are building hammers on this system up to 7 tons.

The single standard hammer by the same makers is illustrated on Plate CCIII., Fig. 3. This hammer is extremely simple in its construction and management, and is chiefly used for forging uniform pieces, such as gun barrels, tubes, sword blades, round, square, and hexagonal steel bars, &c. Like the one formerly described, it is fixed on the anvil block, which is used as a bedplate. The admission of the steam is effected by a simple slide valve worked by a hand lever, as shown in the engraving. From the steam chest the steam passes along passages cast in the top part of the standard, and which communicate with the top and bottom of the cylinder through ports cut into the piston rod and piston. If the piston is at the bottom, the steam passes through a port into a hollow part of the piston rod, and from thence into the cylinder under the piston. When the latter is at the top of its stroke a port cut into the piston communicates with a port in the intermediate flange at the top of the frame, and the steam passes to the back of the piston. Of course the piston is of such length that this port will not be open when the piston has reached the lowest point. For such an arrangement the stroke must be a constant one, and in the present case it is 7½ in., whilst the cylinder has a diameter of 10½ in. The weight of the hammer is 4 cwt., and the average number of blows, when worked with steam at a pressure of 45 lb. per square inch is 360 per minute. The piston rod, 6½ in. diameter, is made of cast steel, and forms, with the piston, one piece, whilst the head is fixed to it by means of cotters. The greatest height of pieces which can be forged under this hammer is 4½ in. The bottom of the frame is 3 ft. square, and its total height to the flanges of the cylinder is 5 ft. 6 in.; the total weight of hammer with anvil and bedplate is 4½ tons; without the latter 2 tons 3 cwt.

Close by the exhibits of which we have just been speaking was shown a machine which, although scarcely coming under the denomination of a tool, may be described in the present section. This was the machine for testing springs made at the Hagmer Steel Works, and illustrated by us on Plate CCIII., Figs. 4 to 6. The construction of the machine is so simple that it will at once be understood from the engravings. The arrangement consists of a long lever carrying weights at one end, while at the other it turns on a fulcrum carried by a nut mounted on a vertical screw, this screw being connected by bevel gear to a spindle carrying fast and loose belt pulleys, and capable of being driven in either direction by the open and crossed straps provided for the purpose. At an intermediate point in the lever provision is made for taking a bearing upon the spring to be tested. The lever is raised by running the nut up to the top of the screw, when the spring being put in its place, pressure is applied by causing the screw to revolve in the opposite direction, thus making the nut descend. This downward movement is continued until by the upward thrust exerted by the spring the outer end of the lever with its weights is raised. The nut is then run up again, another spring substituted for that just tested, and so on. Of course the test load can be applied any desired number of times, and the machine affords the means of getting through the testing with great rapidity.

The last German exhibitor whom we have to notice is C. Kneusel, of Zeuleuroda, who showed a very good collection of light tools for bending,

moulding, &c., tin or zinc plates, the collection also including some roller shears, and rolls. Some of the machines in this series are ingeniously arranged and are worthy of special notice; they could, however, scarcely be clearly described verbally without occupying more space than is at our disposal here.

Austria and Hungary.

The only countries whose exhibits of machine tools we have yet to notice, are Austria and Russia, the latter nation being, however, very small exhibitors. And here we may state the Austrian department of the Machinery Hall contained very few novelties in the way of machine tools, and that, in fact, with but few exceptions, the exhibits of this class were of an inferior kind. In fact, one of the neatest contrivances shown in the Austrian department, was a small portable tool for cutting keyways in shafting. This was a kind of small portable slot drill, worked by a ratchet lever like a ratchet brace, and capable of being readily fixed on any shaft on which a keyway was to be cut. A simple arrangement gave a self-acting traverse to the slotting drill. This handy little tool is the invention of Mr. E. Esslinger, of Vienna.

Undoubtedly the finest collection of machine tools in the Austrian department was that sent by Messrs, Pfaff, Fernau, and Co., of Vienna, of whose exhibits we illustrate some examples on Plates CCIV., Figs. 1 to 4. First amongst these we may describe the very fine radial drilling machine with vertical and horizontal tables, illustrated on Plate CCIV., Fig. 1. This machine is driven by a five speeded cone, and has both single and double driving gear. The radial arm is rotated by means of the hand wheel shown near the bottom of the column, which works a worm gearing into teeth cast round the fixed base of the column. The arm can be raised or lowered by hand by means of the handle with spring catch and ratchet wheel shown in the engraving just in front of the slide. The tool itself receives its rotary motion by gear of the usual kind, and can be moved out and in along the radius arm by means of the vertical hand wheel (with pinion and rack) in front of the tool slide. The feed of the tool is arranged so that it can be made self-acting when desired, in which case it is worked by means of an eccentric on the tool spindle, communicating motion to the second vertical spindle. There is also a hand wheel for feeding by hand. As will be seen from the engraving the machine has a compound table, presenting two horizontal and one vertical face. Each of the three faces is planed all over, and provided with countersunk grooves, and every convenience for attaching the work. The extreme distance at which the tool can be placed from the centre of the column is 2 metres (6 ft. $6\frac{3}{4}$ in.), and the maximum distance between the tool stock, when the arm is raised to its fullest extent, and the surface of the upper table is the same. The breadth of the upper table is 1·110 metres (3 ft. $7\frac{3}{4}$ in.), the height of the vertical table ·770 mm. (2 ft. $6\frac{1}{2}$ in.), the breadth of the lower table 1·27 metres (4 ft. 2 in.), and the extreme length of the lower table 3·200 metres (10 ft. 6 in.). The construction of its table renders this machine specially adapted for drilling complicated or large and heavy castings and it will be a very useful tool in shops where there is much of such work to be done. Its construction is very simple, its workmanship seemed accurate and good, and it was altogether a very well-made tool.

Next in order we may take Messrs. Pfaff, Fernau, and Co.'s triple geared face lathe, illustrated on Plate CCIV., Figs. 3 and 4. This machine is driven by a cone pulley with five speeds; the single and double gear are arranged in the usual manner, and the triple gear has a second countershaft driven off the first, and driving the face plate by means of a pinion working into an internal toothed wheel on its back. The self-acting gear is very complete and very neatly arranged. A speed cone on the end of the mandril prolonged behind the headstock drives another similar cone revolving on a stud fixed in the back of the frame near the ground, and there is a small pinion always revolving along with this cone. Two intermediate pinions, revolving on pins projecting from the arms of a moveable lever, are so arranged that either one or the other of them (or neither of them) can be brought into gear with a

wheel on the end of the motion spindle, according as it is desired to give a forward or backward motion to the slide rest, or to allow it to remain stationary. The motion spindle is clearly shown in the side view of the lathe, and it gives motion to the small pinion working between the two wheels seen in the end view. The wheel to the right of the pinion moves the whole rest to or from the face plate along the main bed of the machine. The wheel to the left serves the purpose merely of transmitting the motion to another horizontal spindle passing under the side of the slide rest. Through this spindle, by means of suitable gearing, either the whole upper part of the slide can be made to receive the self-acting traverse motion, or the motion can be transmitted (by means of a vertical spindle running up through the cylindrical part of the rest) to the upper slide only. The whole top slide can be set at an angle by means of a slot and two adjusting bolts, but as the vertical spindle passes up the centre of the column, the bevel wheels by which its self-acting cross feed is given remain in gear, so that this motion remains self-acting, no matter at what angle the slide is placed. The upper slide, or tool box, has also a separate motion to and from the face plate, but this is not self-acting. Both the motions of the main slide rests, and also the cross feed motion of the tool slide, can be worked by hand as well as by the machine itself. The face plate is of the usual construction, and fitted with four adjustable screw claws. The whole machine is very substantially and strongly made and well finished, and is altogether a good specimen of Continental tool making. The lathe can take in an article 1·650 metres (5 ft. 5 in.) in diameter by ·550 mm. (21½ in.) long.

The last exhibit by the makers whose tools are under notice which we can describe here is the double-drilling machine illustrated on Plate CCIV., Fig. 2. It is a form of tool which is not common in England, but which possesses several advantages, and of which there were a number of specimens in the Exhibition. The larger drill is double geared and is driven by a cone with four speeds. The tool receives its revolving motion by bevel gear in the usual way. The downward feed is arranged both to be self-acting and to be worked by hand. In the latter case it is given by means of the small hand-wheel, while in the former case a small eccentric rod worked by a steel eccentric on the drill spindle immediately underneath the bevel pinion is made to work a spring ratchet which communicates motion to a ratchet wheel on the same vertical spindle with the hand wheel. This drill has, as will be seen from the engraving, two tables; the upper one is circular, and is supported by a radius arm capable of being pushed aside out of the way when necessary. The pin in which this arm works is made very large in diameter in order to prevent as far as possible the wear to which such an arrangement is necessarily subject. The whole upper table with its bracket can be moved up and down by hand by means of a worm and worm wheel, pinion, and rack. The lower table is fixed, and forms a kind of base plate for the whole machine.

The second or smaller drill has only single driving gear, with a three-speeded cone, the feed of the tool is arranged in the same way as described above, either to be self-acting or to work by hand. It has only a single table, which has a raising gear similar to that of the opposite table, and it has in addition a hand cross traverse. The framework of the machine is everywhere in section a hollow rectangle, which gives solidity in appearance as well as in reality. The principal dimensions are as follows: Diameter that can be taken in by large drill 1·300 metres (4 ft. 3 ft.), maximum distance between drill stock and face of top table 600 mm. (23½ in.) maximum distance between drill stock and face of lower table 1·300 metres (4 ft. 3 in.). Diameter that can be taken in by small drill 800 mm. (2 ft. 7½ in.), maximum height between drill stock and face of plate 350 mm. (13¾ in.).

The K. K. Privilegirte Maschinen Fabrik Th. Schultz and L. Göbel (Vienna), exhibited at Vienna the 50-cwt. single-acting steam hammer, of which views are given on Plate CCV. It does not embody anything specially new in its construction, but is a simple, substantial, and well-arranged machine; Fig. 1 is a side elevation of the whole hammer, with a

section of the valves; Fig. 2 is a vertical section through the centre of the hammer; Fig. 3 is a part sectional plan, the section being taken through the guides; Fig. 4 is a cross section through the cylinder and valve boxes; Fig. 5 is a cross section of the cylinder brackets above the level of the side frames, and Fig. 6 is a section showing the fitting of the piston rod in the tup.

The cylinder is 12 in. in diameter, and has a stroke of 5 ft. Austrian measurement. It has hollow wing brackets, *a a*, shown in section in Fig. 5, resting on the top of the two side columns, and its lower end, for the length of 19 in., lies between these columns and is bolted to them, as seen in Fig. 4. The valves are three in number, a throttle valve *b* in the main steam pipe, an admission valve *c*, and an eduction valve *d*. The throttle valve is made of brass, and is of precisely the same shape as an ordinary Corliss valve. It is worked by a simple gear from a hand lever *e* on one of the side frames. The steam admission and eduction valves are both double-beat equilibrium valves working on brass seats, and they are held in their places by helical springs acting on this spindle. Their action is very simple, being controlled by a single handle; the following description will make it easily intelligible: The tup is shown in its lowest position; suppose it is desired to lift it, and make a stroke on the anvil. The lever *e* is first worked so as to throw open the throttle valve *b*. The rod *f*, which is connected with the bell crank *g*, is then pushed into the position shown in Fig. 3, and the bell crank is thus disengaged from the end of the lever *h*. This lever is keyed on to the vertical spindle *k*, and on the upper end of this spindle are two levers, one communicating with a spring at *p*, and the other working the steam valves through the cranked lever *m*. As soon as *h* is disengaged the spring at *p* pressing outwards, turns the spindle *k* through a small angle, and by lifting the right-hand arm of the lever *m* opens the admission valve, and allows the steam free access to the under side of the piston, which it, of course, immediately raises. A lever *n*, carrying at its end a roller *o*, is fast on the spindle *k*. Before the tup quite reaches the top of its stroke the face *q* comes into contact with this roller and presses it back, so that the whole motion of the valves is reversed, the left-hand arm of the lever *m* is raised, and the eduction valve thereby opened, the steam valve being closed by the spring above. The steam below the piston is thus free to rush into the atmosphere, and the tup falls by its own weight.

The tup is guided by projections extending throughout its whole length working in channel grooves in the standards. These are of cast iron, and extend down through the girders (to which they are secured by the bolts *r r*) and considerably below them, as shown in Figs. 1 and 2. The girders themselves are of wrought iron, their design being much the same as in the great 15-ton hammer of the Märkische Maschinenbau Anstalt, already described. Their construction is clearly shown in the engravings; they are 2 ft. 6 in. deep, and 2 ft. 7 in. apart. They are supported at each end by a cylindrical cast iron column 4 ft. 10½ in. high, 1½ in. thick, and having a mean diameter outside of 3 ft.

Wrought-iron tie rods, one on each side, are placed between the feet of the columns. The arrangement of anvil, &c., does not call for any special remark; it is all distinctly shown in the engravings. The piston is of wrought iron, with a single steel spring ring. The only point which it remains to notice is the fixing of the piston rod in the tup, shown in Fig. 6. The piston rod is of steel, and is made with a spherical end, and to allow for this the stuffing box gland is made in halves. Fig. 6 is a section through the centre of the tup, it shows clearly the method of connexion, and it will be noticed that when the tup is being lifted its whole weight comes on the two large keys *s s*. This method of fastening seems a good one. We notice that the maker of this machine, in common with many others, have got still to learn the lesson on which Mr. John Maudslay used to insist so strenuously, that "nature abhorred" a square corner, at least to the extent that in castings all inside corners should be well rounded off. The radii of the corners in this hammer would, in several cases, be the better of being quadrupled, or even

more. In other respects it is a good substantial job, no attempt having, however, been made at high finish.

The same firm also exhibited a compact little shearing machine, of which we give views on Plate CCVI., Figs. 1 to 4. The engravings are so distinct that a few words of explanation only are needed with them. The engine is of the common steeple type, the valve being worked from a very much overhung return crank. It has a cylinder 6 in. diameter by 12 in. stroke. The engine's shaft is thus kept very low down; and it drives the main shaft which is directly above it, by spur gearing of 6 to 1. The flywheel is of such a diameter as just to clear the under side of the main shaft. The shears are worked direct by a pressure link from an eccentric pin on the main shaft, the cutter block being raised by a wrought-iron connecting link with a slotted eye at its upper end, seen in Fig. 1 in section, and Fig. 2 in elevation. The pressure link can be pulled out of gear by a simple arrangement of levers shown to the right in Fig. 2, and also in plan in Fig. 4. As soon as it is out of gear, the balance weight on the lever raises the cutter block, which remains stationary, as the slotted eye above referred to allows the pin in the end of the shaft to move freely without affecting the position of the cutter. The holding-down bolts of the front bearing of the main shaft are carried right down the slides of the standard to the foundation to insure stiffness. The two standards are cast separately, and bolted and joggled on to a flat bedplate, which itself is bolted through to the foundations. Some extra width might have been advantageously added to the feet of both the frames, to give steadiness under the jars and jerks to which such a machine is necessarily subjected. On Plate CCVI., Fig. 1 represents a longitudinal section of the machine, Fig. 2 a front, and Fig. 3 a back elevation, and Fig. 4 is a sectional plan.

Messrs. Escher, Wyss, and Co., of Leesdorf (a branch establishment of their well-known works at Zurich), besides showing a steam hammer on Farcot's system (illustrated on Plate CCVI., Fig. 9), were the exhibitors of a good substantial railway wheel lathe, and of a wheel-cutting machine, neither of these tools, however, possessing any special points of interest. The same remark will, in fact, also apply to the collections of the other Austrian tool makers. Thus Herr W. Schwabe, of Vienna, only showed a spring hammer of American design, and a small lathe and screwing machine, both of ordinary patterns; Herr Johann Müller, of the Maschinen und Hilfswerkzeug Fabrik, Vienna, showed, in addition to an ordinary lathe and planing machine, a drilling machine arranged so that the spindle could be turned out of line with the table, it being then prolonged by a boring bar extending down to a bearing in the bed plate, the latter being grooved for fixing work; Herr Johann Hipp, of Vienna, exhibited some small hand lathes with wooden frames, and fitted with elliptical chucks, these lathes being of somewhat rough workmanship, but including some good points in their details; while, finally, Herr Rainer Nassimbeni, and Herr Anton Horak, both of Vienna, likewise exhibited some small hand lathes, requiring no special notice. The only other exhibit of tools in the Austrian department of the Machinery Hall was in the sub-section devoted to Hungary, where Herr F. Zimmermann, of Pesth, showed a railway wheel lathe of ordinary design, but good proportions and workmanship.

Lastly, in taking leave of the Austrian exhibits we must notice a handy little contrivance for cutting off locomotive stay bolts, which was exhibited in the pavilion belonging to the Kaiser Ferdinand's Nordbahn. It is a very neat little tool for cutting off fire-box stays to the required length before rivetting over the ends, and it is illustrated, half size, on Plate CCVI., Figs. 7 and 8. It consists, as will be seen, of a shank or base, having an eye bushed with steel, the face of the eye having turned on it a shallow annular rib, which is eccentric to the hole in the eye itself. Fitting on this rib is a steel ring held by four screws, this ring serving to hold in place a boss, the collar on which fits the ring just mentioned, while a hole pierced in it is in one position of the boss concentric with the hole in the shank. On its face next the shank the boss is recessed to receive a steel cutter in the form of a ring, this cutter entering slightly into the face of the shank, and being prevented from turning

in the boss by a rivet, as shown. The projecting part of the boss is made hexagonal to receive a wrench, while the tool, when placed upon the stay to be cut, is prevented from turning round by the shank bearing against the next adjoining stay. It is evident that, as the boss is turned, the fact of the centre on which it revolves being eccentric to the hole through which the stay passes will cause the latter to be sheared by the steel cutter ring. One man can in this way easily shear copper, iron, or even steel stays 1 in. in diameter. The ring form given to the cutter is a convenient one, and enables it to be readily renewed.

Russia.

Russia, as might be expected, was an even smaller exhibitor of machine tools than Austria. In fact, the only exhibits from Russia were a very ordinary screw cutting lathe from Mr. G. A Lessner, of St. Petersburg, a wall drill and hand drill from the Alexandrowski Technical School, and a small lathe, a small hand-worked shaping machine for fixing to a vice (illustrated on Plate CCIV., Figs. 5 and 6), and a handy form of vice (illustrated on Plate CCI., Figs. 15 and 16, shown by the Technological Institute of St. Petersburg. These latter exhibits, being made by the students, could not be too closely criticised, but the workmanship was very fair considering. The lathe, however, had some rather doubtful points, and looked more like the model of a larger lathe than a full-sized tool. We have now completed our general survey of the machine tools shown at Vienna, and we trust we have enabled those of our readers who did not visit the Exhibition to gain a fair impression of the character of the exhibits of the various nations represented.

WOOD-WORKING MACHINERY.

The exhibits of wood-working machinery at Vienna were so varied and numerous, that they ranked among the leading objects of interest in the Machinery Hall. Nearly every country contributing to Group XIII. included some machinery for the working of timber, and the number of tools was so great that it was a work of considerable labour to inspect them all. In noticing these machines, the natural order to have taken them would be in groups of each class of tools, such as saws, planing machines, tenoning and mortising machines, &c. But it will be more convenient to consider them by the different nationalties.

United States of America.

The United States of America, to which was assigned the western extremity of the building, occupied but a small space, and their exhibits were not numerous. On the other hand, they were extremely well selected, and most of them were new, at least to the majority of visitors at the exhibition. In wood-working machinery this section was especially rich, and, thanks to the tools of Baxter D. Whitney, of Winchendon, Massachusetts, found no rival in any part of the building. There is a striking originality about this American wood-working machinery. The tools of English makers have all a more or less marked family likeness, and, for the Continental manufacturers, although, as we shall presently see, there are many new and extremely good machines, there is too evident in this as in almost all other branches of mechanical industry, the enervating influence of servile imitation. Mr. Whitney's exhibits comprised, besides several tools for ordinary work, some special machines, which, when in operation, never failed to attract large crowds of visitors. These were the machines for making pails, and cutting barrel staves, and which are illustrated on Plates 207, 208. The pail-making plant consists of only two separate machines, although the larger of these

comprises a number of small tools mounted on one common frame. The smaller is a cylindrical saw, Figs. 4, 5, Plate 207, and is employed for cutting the strips which form the pail staves; this operates in precisely the same manner, but the work being of course light, a travelling carriage is dispensed with, and only a flat table is placed as far below the centre of the saw as corresponds to half the width of the stave. Two curved stops are bolted to this table, inside the cylindrical saw, corresponding to the thickness of the stave itself. A curved saw cut is made in the table, through which the saw works. In operating this tool the block of wood is simply pressed against the stops, and fed up to the saw, which cuts off pieces curved to the form of the saw, and of the thickness required.

The staves being cut, they are taken to a second machine, see Figs. 1, 2, 3, Plate 207, which comprises nearly all the tools required for the production. The necessary taper is first given by means of a circular saw. The stave is placed upon a block rest curved to the same radius as the cylindrical saw, and mounted on a slide in front of the circular saw just mentioned. A cut is made through the centre of this block, for the saw to travel freely in, and a wooden gauge, jointed to the centre of the block, corresponding to that of the finished pail, is free to sweep over the curved block. The stave is first placed upon the rest, so that one edge just covers the cut within it, the slide is then advanced, and the saw cuts off a square edge. The stave is then shifted over to the other side of the block, and is brought against the gauge before mentioned, and by which the width of the stave is regulated. The slide is once more advanced, and sufficient is taken off by the saw to give the desired taper to the stave.

The next operation is that of cutting the stave to a proper length; this is very simply performed by two circular saws, set at the proper distance apart, while the stave rests upon a suitable bearing. The third tool upon this combined machine is that for matching the staves. For this, two sets of revolving cutters are employed, one for cutting the grooves, and the other the tongues; one blade, however, in each cutter is flat, in order to trim the edges of the stave; the other cutters on one side are very narrow for cutting the grooves, while on the other side they are broad and recessed in the centre, for forming the tongues. The depth to which these are cut, however, is very small, the matching being only sufficient to prevent the staves of the pail, when completed, from shifting. A sufficient number of staves to form the pail are then set up together and placed between two revolving discs, mounted on the same frame. One of these discs is fixed, and the other is free to slide, in order that the pail may be securely fixed, and afterwards easily removed. Three operations are performed in this part of the machine; the outside of the stave is first turned down, a block covered with sand paper is then brought over the revolving surface to give it a finish, and finally, the upper hoop is placed on. This hoop is slipped over the smaller end of the pail, and a lever hinged to the back of the machine is thrown forward. Near the front end of this lever is placed a small and freely-revolving disc, with a concave periphery. The position of this disc is such that when it is brought forward it bears upon the surface of the pail, and by pressing the disc against the hoop, the latter is gradually forced upwards into place.

The pail is then removed, and placed within an iron drum mounted at one end on a shaft, on which is a pulley, driven by the same power as actuates the other parts of the machine. The drum is provided with a wooden lining having the same taper as the bucket, in order to prevent the latter from being bruised by contact with the iron. In this part of the machine the work is advanced three stages; first, the inside is turned by a cutter placed in a cutter bar, which being mounted on a pin is free to turn horizontally; second, the top edge is bevelled by the same tool; and, third, the groove near the lower end, in which the bottom of the pail fits, is cut by a second cutter mounted on the same bar. The pail is then taken out of the drum, the bottom which has been made at another machine, is sprung into place, the pail is set up on a mandrel and a bevel is given to its lower edge.

Though, as we have already said, these machines are little known in this country, they are in extensive use in the United States, and the attention

paid during the first weeks after the opening of the Exhibition to these exhibits of Mr. Whitney by the visitors, would seem to point to the probability of their becoming acclimatised in Austria. We say the first few weeks, because, thanks to the discreditable arrangements in force at the Exhibition, Mr. Whitney was charged a tax upon each pail he produced. As the machines must either stand still or make pails, and as Mr. Whitney declined to be victimised by this official extortion, he returned to America early in the summer, and the machines remained unworked. We may mention in conclusion, that the average production of these machines is 300 pails per day.

Apart from the ingenuity displayed in the conception of this manifold machine, the manner in which it has been carried out reflects the highest credit on Mr. Whitney. Every one of his exhibits indeed showed the hand and mind of a master, and every other exhibitor of wood-working machinery could and probably has learnt a good deal from these tools. Another special machine exhibited at this stand, was the barrel stave saw, consisting of a large cylindrical saw, and an ingenious feed motion. Figs. 4, 5, Plate 207.

One of the most ingenious and effective machines of the group furnished by the same exhibitor was a small gauge lathe for turning. This lathe turns out small pillars, such as are used in offices and for the backs and legs of chairs with accurately formed mouldings and bulgings upon them with remarkable rapidity, and it will now be proper to explain the nature of the mechanism by which this is accomplished.

The rough piece of wood which has to be turned is placed between centres, one of which is formed in the manner of a serrated disc, so as to grip the end of the piece of wood to be turned, and the other is provided with a central raised point and slightly raised rim all round the small disc which constitutes the end of the spindle. The latter is set up or withdrawn by a hand-wheel. The wood to be turned is rotated by one of the pulleys, and is first reduced into the form of a cylinder, which is done by means of a fixed chisel set in a slide rest, which is drawn forward on its bed in the same manner as any common slide-rest by means of a screw driven by a pulley. The slide-rest has two chisels in it—one the fixed chisel already mentioned, and the other a chisel susceptible of a slight up and down motion by being fixed to a movable frame hinged to the main slide. This slide has an eye upon it, which runs back over the centre, and this eye, which is of the exact diameter of the cylinder which is first turned, advances with the chisel so as to steady the thin pillar near the part encountered by the cutting edges of both chisels. Forming part of a frame, and capable of sliding up and down in guides, is a diagonal piece, to which the diagonal knife is also firmly bolted. From a pulley a heavy weight is suspended by a leather strap to counterbalance this frame, and which it does by means of a shaft, which carries pinions working into racks on the sides of the sliding frame. There is a narrow gauge piece of iron or steel, about $\frac{1}{4}$ in. thick, cut out to the shape of the mouldings and bulgings the pillar is intended to have, and the knife, which is brought down at a tangent to the pillar, while it has its cutting edge in a straight transverse line, is moulded on the face or side to the contour of the pillar. The movable chisel attached to the hinged part of the slide rest is moved up and down by means of a projecting foot, which presses upon the gauge or corrugated rail as the rest advances, thus cutting the piece of wood which before was a cylinder into the proper form. But as the slide rest is advanced by the screw a notch in the rest which engages the projecting flange of the diagonal bar brings down the frame in opposition to its counterweight, and with the frame the moulded knife or blade by which the turning operation is completed and the pillar accurately finished and smoothed. Of course a different knife and gauge rail will be required for every different pattern of pillar. But the other parts of the mechanism will remain without alteration, whatever contour or mouldings are employed. For the purpose for which it is intended nothing can be more rapid and efficient than this lathe, and a similar device might with advantage be introduced to form the pillars of balustrades in stone in all cases where a large number of them is required.

By this machine the operation is enabled to complete rails 34 in. in length, and from $\frac{3}{16}$ in. diameter upwards.

Mr. Whitney had also two saws, both of an excellent construction, and possessing some striking novelties. The larger of these two is a band saw, and has three distinguishing features (see figs. 6, 7, 8, 9, Plate 207). First, the wheels over which the saw runs are made concave, in order to secure a bearing in the direct line of pressure from the saw blade, and to obtain a certain amount of elasticity to compensate for any sudden shock thrown upon the saw at any time. Second, the shaft upon which the upper saw wheel is secured, runs in bearings connected with a rocking shaft, which rests in adjustable boxes secured to the sliding plate at the upper part of the machine. From the rear end of the rocking shaft an arm projects in a direction opposite to that of the wheel, and upon this arm is placed an india-rubber spring covered with a cast-iron cap. This spring is kept from lifting by a bolt passing through the cap, spring, and arm, and is screwed into a bracket projecting from the sliding plate. The elasticity of the spring always keeps the wheel in such a position as to maintain the saw in tension. Any expansion, however, of the saw during use is immediately taken up by the spring, which allows equally for a contraction of the blade. The working of this arrangement is so perfect that, practically, the smallest variations in the length of the saw blade by change in temperature are indicated by the movements of the rubber spring. The third special feature of the saw is as follows :—In the foot of the vertical bar above the table is a square socket, in which is placed a metal block carrying wooden side guides, in which are pieces of felt kept saturated with oil for the purposes of lubrication. Immediately behind these guides is placed a steel disc to resist the backward thrust of the saw. This disc is fixed at the front end of a spindle, which passes back through the metal block, and terminates in a worm gear, engaging with a worm on a vertical shaft, mounted in bearings attached to the vertical bar. This shaft is driven by a belt from the shaft of the upper saw wheel. The steel disc behind the saw is thus caused to revolve slowly, and as the centre of the disc does not coincide with the centre line of the saw blade, it presents, when rotating, a constantly changing surface to the back of the blade, and being in contact with the oiled felt in the wooden guides, it is constantly lubricated, and wear is prevented alike on the face of the disc, and the back of the saw blade.

In connexion with this we may mention a variation of the saw guide, adapted to single blade log frames, which are used especially for cutting the more costly woods, which it is more economical to separate plank by plank than to cut up the log at one operation. This guide is mounted on a small frame, and can be adjusted to any required angle, in order to compensate for any bias or irregularity in the saw blade.

A fret saw of very excellent design was also comprised in these exhibits. It is driven by a pulley mounted on a small double crank-shaft close to the foot of the machine. Connecting rods of wood are attached, the one to a vertical bar, the other to the saw frame itself, and which slides in guides formed by the vertical bar just mentioned, and the weight of which exactly corresponds to that of the saw frame. From the lower part of the bar projects a horizontal arm, acting only as a balance. The disposition of the material is such that the centre of gravity of the balance coincides exactly with that of the saw frame, so that the machine runs in perfect equilibrium, and with great ease and smoothness. One very ingenious detail is noticeable in this exhibit. It is the means provided for holding the upper end of the blade, and permits within certain limits, a variation in the length of the blade employed. The sketch (see figs. 8, 9, Plate 208,) will serve to explain the arrangement of this detail. In the block at the end of the saw bracket is a square hole, through which passes freely the shank of the hook *b*, which is split to receive the saw blade *h* the latter being secured in place by a small pin passing through a hole in the top of the blade, as shown. The upper part of the shank *b* has a screw thread cut upon it, and a broad slot is formed through this screwed end down into the square part of the bar. In this slot a loose piece *c* is fitted, this piece having a square top, while the lower end is formed with a semicircular groove. A cap *a* is screwed

down over the top of the bar. A small eccentric lever of the form shown at *f*, *g*, passes through holes in the block of the frame. This eccentric is made out of one piece, the centre part *g* being turned down to such a size that it plays freely in the slot of the hook bar before mentioned. The side discs *f* of the lever turn in the holes of the block, which are made so as to leave sufficient space to allow the eccentric bar to move vertically up and down in the slot. This eccentric is actuated by a handle *e*. When it is desired to remove the saw, and to replace it by a shorter one the cap *a* is removed, the sliding piece *c* is taken out of the slot, and the hook bar falls, leaving the eccentric lever in place. When the new blade is inserted in the hook the bar is again placed through the vertical hole in the block, the sliding piece *c* is replaced in the slot, and the cap *a* is screwed down as far as it will go, the distance depending on the amount to which the blade has been shortened, and the hook bar brought down. The strain from the saw blade is of course carried by the eccentric of the lever *e*.

Whitney's scraper for hard woods is also a very perfect machine, which which will probably recommend itself for adoption in England. It is a small tool containing four rolls, in groups of two, mounted on springs, and the pressure exerted by which can of course be regulated; between the pairs of rolls is space for an iron block containing a knife, the edge of which is of a peculiar form, as shown in the sketch. The edge of the knife is very carefully adjusted, so that it is almost flush with the surface of the block in which it is set. The block being placed in the machine, the timber is fed in between the rolls, and a very fine shaving is taken off by the blade, leaving the face of the wood truly squared, and beautifully surfaced. Although the edge of the knife is so delicate, it needs but little attention, and with care, will scrape as much as 4,000 lineal feet of hard wood without requiring to be set. In connexion with this little machine is another, forming an essential addition to it, namely, the tool for grinding the knife required for the work (Figs. 1, 2, 3, Plate 208.) This tool consists of a framework carrying two jaws larger than the knife, and between which the blade is placed and secured. It is then brought for its whole length under the action of two revolving emery wheels, one of which grinds one face up square, and the other puts the bevel on the back. The small feather edge on the knife is produced by means of a vertical tool placed over the centre of the line of motion of the traversing jaws holding the knife, and beneath which the cutter passes; the bottom of this tool is so arranged that the sharpened edge, in passing under this bar, and in contact with it, is turned over to the required angle (Figs. 6, 7, Plate 208.)

There remain a few more machines yet to be noticed in this interesting series of exhibits; first, a double circular saw bench, the two saws, one of which is used for splitting, and the other for cross cutting, being mounted on the same frame. By turning a handle at the side of the bench, either one of the saws can be brought up at will, the other being lowered out of the way. They are both driven off the same belt, which is always kept over both pulleys fixed on the saw spindles; but it is only when either of the saws is in its highest position, that is to say, when it is ready to be operated, that the belt is tight enough to drive it. There are provided with the machine a number of useful rests, which can be fixed by means of pins, and holes made in the table to receive them.

Figs. 10, 11, Plate 208, represent Mr. Whitney's machine for planing wood. This tool is designed for planing one surface of the wood only by means of a revolving cutter shown in section *f*, of fig. 10. This cutter is provided with two continuous straight blades as knives, one set against a counter blade, like the finishing cutter of a joiner's plane. The spindle carrying the cutter is held on bearings fixed to the framework of the machine itself, and does not allow of any movement in the vertical direction, like the spindle of most other planing machines. The difference of thickness to be planed, is in the machine, allowed for by the provision for raising and lowering the table or bed upon which the timber is placed. The bed *l* is as shown in fig. 10 placed upon an inclined plane *m*, of which it forms the counter part, and upon which it slides longitudinally, when moved by means

of the screw m^4 and nut m^2, the movement of the table l forward and backward upon the inclined plane m causes the horizontal which forms the top of the table, to rise or fall in a corresponding proportion, and the whole is geared so that one revolution of the hand wheel and screw m^4 will raise or lower the top of the table vertically $\frac{1}{8}$ in. Mr. Whitney prefers the adjustment of the table to that of the spindle, as adopted by most other machine makers, because he is thereby enabled to secure the bearings of his cutter spindle more firmly to the framework of the machine, and thus avoid the principal source of vibration in the action of his machine.

Mr. Whitney is careful to arrange all his gearing so as to obtain no vertical strain upon his rolls from the gearing in either direction. There is, of course, equal danger in the tendency of the gearing to lift the rollers, as in a pressure downwards upon the work, as in either case the inequalities of grain or structure in the wood produce an irregular effect upon the rolls, and the result is the production of a more or less undulating or uneven surface. Another important point about Mr. Whitney's planing machine is the manner in which the feed rollers are geared for the purpose of effectively avoiding any accumulation of pitch and other gummy substances upon the surface of the feed rollers. The wood and shavings after being fresh cut by the revolving planer have a tendency to cause a quantity of such gummy substances to adhere to the surface of the rollers, and to accumulate upon the latter, so as to cause indentations in the plane surface, in consequence of the irregular and vibrating movement of the whole and the irregularity of the roller surface itself. Mr. Whitney avoids this effect by giving the surfaces of the feed rollers in front of the revolving planes and to those behind the latter a slightly different speed of motion, so as to effect a constant slipping of the back rollers upon the surface of the wood. This stopping or rubbing action very effectively prevents any irregular accumulation of adhesive matter, and very completely prevents the consequences observed to take place without this precaution. Mr. Whitney patented this mode of gearing the feed-rolls of a wood-planing machine a few months ago.

The circular-saw bench already mentioned carries two different circular saws, mounted on a double armed bearing, which is turned round a fixed spindle by means of a worm and worm wheel, worked from a handle at the side of the machine framing; the rotating of the fixed spindle causes either of the circular saws to rise or fall in the narrow slot of the table through which the saw projects, and a still further movement will cause the saw at the top to disappear entirely, and to change places with the other saw, which will then come up through the slot, and may be set at any required height, like the other saw. Both saws rotate in the same direction, and they are driven from a belt having its driving pulley below the table, but only one of the two pulleys and saw spindle which stands above is in contact with the belt at one time, so that only one of the saws is in rotation whilst working and the other below the table is at rest until it is brought up in its turn when wanted. The object of fitting up two saws is to provide for the different requirements of the wood when cut parallel to the grain or across the latter. The two saws have accordingly teeth of different size and shape, one being adapted for parallel, and the other for cross grain. The feed motion for the wood in a straight line is obtained through that part of the table which carries it. This table is mounted upon a slide, and can be traversed horizontally in a straight line. The set of adjustable gauges and guides makes this machine very complete and useful for a variety of work, all of which it finishes with great nicety and accuracy. There is a circular gauge for cutting at any required angle through its end. Another guide for gauging the width of long, parallel, or taper pieces was exhibited, and this is adjustable also vertically, so as to cut a bevilled side of a parallel piece. Furnished with all these adjustable guides and templates, and finished with nicety and accuracy as this machine, it allows of the production of unusually neat and delicate work, and recommends itself as a model for very general imitation in England and on the European continent.

Finally, there was a small double boring machine, with two drills, especially adapted for boring tenon holes for upholsterers' work. A sliding and tilting

table allows the timber to be brought up to the drill at any desired angle, and the drills are mounted in a standard which turns freely around a centre, but which can be locked in any position by means of a T-bolt, the head of which works in a suitable slot formed around the periphery of the joint upon which the arm turns. Of the two drills, one is driven direct by a pulley mounted on the end of its spindle, and has moreover teeth cut around the spindle where the diameter is slightly increased; these gear into a spur wheel, which again drives a corresponding spindle on which the second drill is mounted.

We have given considerable space to describing Mr. Whitney's machines, and have illustrated the greater number of them, because his exhibits are altogether far beyond any other wood-working tools in the United States section. The design and construction are alike excellent, and every detail is worked out with the utmost care. Of the remainder of the American wood-working machines we must speak briefly.

Near to Mr. Whitney's stand were a planing machine and another tool exhibited by the agent of Messrs. Witherby, Rugg and Co. of Winchester, Massachusetts. These machines are crude. We may, however, note one detail in the planing machine, of more than doubtful utility. The guides, close to the side cutters, against which the timber presses in passing through the machine, are rigid only on one side; on the other the guide is hinged to a pin in the frame, and is kept up to its work by a heavy spring; if, however, any irregularity in the timber opposes itself, the spring yields, the object being to give a greater uniformity to the action of the cutter.

Far better than these machines were those of Mr. J. A. Fay, of Cincinnati, Ohio, who had a collection of tenoning, mortising, and boring machines, together with a band saw, the design of the upper wheel of which must be seen to be believed. The mortising machine has one or two details worth noting. The angle of the pedal, which raises or lowers the table on which the work is fixed, can be regulated to the height of the work, and to suit the convenience of the workman. The cutter bar is worked by a connecting rod pinned to a disc on the spindle, which has, besides the main pulley a smaller one, driven by a strap, which gives motion to a bevel wheel near the lower end of the cutter bar, gearing into another wheel upon it. This latter wheel has a key way cut in it, and, while free reciprocating motion is imparted to the cutter bar by the disc, the bevel gearing has always a tendency to rotate it by the key in the key-way of the same. This tendency is, however, checked by a horizontal cam with two detents, which works within a horizontal collar, having projections corresponding to the detents in the cam, and always abutting against one or other of them. The belt, therefore, slips on the pulleys, until the automatic means provided for reversing the bar come into operation. Each time that the table is raised by the foot, to bring the work up to the cutter, a vertical bar at the back of the machine is also raised; this bar has hung loosely to its upper end a small escapement lever with bevelled edges. Now the collar just mentioned as encircling the cam on the cutter bar is provided with a horizontal bar with suitable projections, and passing to the back of the machine; and when the vertical bar falls, on account of the table being lowered, the escapement is caught in its descent by one or other of the projections, and the collar is thrown either backwards or forwards, according to circumstances. This motion, of course, relieves the detent, and, the resistance being removed, the strap ceases to slip, and the bevel gearing drives the cutter bar round for half a revolution, reversing the tool. This operation is repeated every time the table is lowered. The arrangement is exceedingly ingenious, and would appear to work well, but is inferior to the reversing motion in the Ransome mortisers. The tenoning machines of Mr. Fay call for little comment. They are excellent neither in design nor in workmanship, although they are doubtless durable and serviceable machines for light work, and may be well adapted for the special duties for which they are intended.

Messrs. C. B. Rogers and Co., of Norwich, Connecticut, had quite a good exhibit of machines at their stand, so far as selection went, but they were lamentably deficient in design and workmanship, and we would scarcely like to consider these tools as the fair type of their usual work. One detail

recommended itself for notice in their tenoning machine, the mode of regulating the relative position of the horizontal cutter spindles. The upper of these is adjusted by a hand wheel and screw, which is bored out, and through the centre passes a smaller rod terminating above the wheel in a horizontal lever and handle. Two set screws control the acting of these wheels. If it be desired to raised the lower cutter spindle, the set screw of the upper one is adjusted; if the upper spindle is to be altered in position, the lower set screw is tightened; by loosening both screws the hand wheel will operate the cutter spindles simultaneously. The hub-mortising machine by this firm shares the condemnatory features of their other tools, and possesses no remarkable details. It, however, appears to be a complete and efficient machine. The cutter bar here is reversed by hand, by throwing over a stop to the right or left, which comes in contact with a spiral-path on the cutter bar, and thus changing its direction. The spaces for the mortises are set out automatically by a dividing wheel, and there are complete arrangements for altering the angle of the table in each direction, so as to obtain tapering mortises of any desired inclination.

Finally, in this notice of wood-working machinery in the United States section we may mention the pin dovetailing machine that was exhibited by Mr. T. Hall, of Florence, Massachusetts, an ingenious and very effective machine which is illustrated by fig. 9, Plate 215. It is an ingenious and valuable machine, the striking peculiarity being that the joint is made with round holes and pins, both of which are formed, exactly to gauge, by the machine. The band saw by Mr. John Richards of Messrs. Richards, Kelley, and London, Atlantic Works. The machine exhibited represented no specially prepared tool, but was simply one sent from the store rooms of the company in Philadelphia to Vienna. The little detail for throwing the dust that is brought down by the saw off the wheel is simple, consisting merely of a small triangular piece of wood placed between the saw and the wheel, the apex coinciding with the centre of the blade. Thus any sawdust adhering to the latter is intercepted by the block of wood, and falls away to the right and left upon the ground.

It is difficult to establish, as we have said, a comparison of the merits of these American wood-working machines with those of other countries exhibited at Vienna. Mr. Whitney's tools are for the most part specialities, and these, as well as his more ordinary machines, such at saws, borers, &c., show a refinement of detail which is unsurpassed, and are at the same time thoroughly practical. On the contrary, most of the other machines exhibited fell so far below even a liberal standard of average merit that we scarcely believe that they are to be accepted as the representatives of this branch of industry in the United States.

England.

We have said that the special nature of the wood-working machinery exhibited at Vienna in the United States section, renders it impossible to institute any detailed comparison between it and the wood-working tools produced by English manufacturers. There are, however, some exceptions to this remark, as for example, in saws, planing and moulding machines, and some others, the design of which may be well compared with the similar tools of other countries.

In glancing over the exhibits of wood-working machines in the English section, we find that the most ingenious of the special tools, as well as some of the best details of the ordinary ones are American. For instance, Armstrong's dovetailing machines, made and shown by Messrs. Robinson and Co., or the Richards mortising machine at Ransome's stand. But these importations, of course, formed only the exceptions, and the exhibits fairly represented, therefore, the present condition of this industry in England, and the progress that has been made in it of late years. The exhibiting firms were Messrs. Thomas Robinson and Sons, of Rochdale, Messrs. Samuel Worssam and Co., of Chelsea, Messrs. Charles Powis and Co., Messrs. Powis, James, and Co

and Messrs. Allen Ransome and Co., of Stanley Works, Chelsea. Let us say at once of these makers, that they had all very complete exhibits, that each had some speciality, some details of excellence, or points for commendation; thus, Robinson's tools are conspicuous at the first glance by the solidity of their frames, and the excellence of their workmanship; Worssam's stand attracted special attention from his parquetry machines; Powis, James, and Co., showed fair examples of their regular work; and Messrs. Ransome and Co., who occupied the best position of all, that at the end of the British section, had a large and perfect series of tools of their newest types.

We find that one of the novelties in the wood-working exhibits to be seen at the stands of three, at least, of the makers, was the so-called semi-portable log frame.

Let us take the stand of Messrs. Robinson and Son first, for detailed consideration.

The object of this tool is to supersede the use of the old frames, which required strong, and sometimes very costly, foundations, and to make a self-contained machine, which may be laid upon balks of timber, or blocks of stone. Such an arrangement recommends itself especially abroad, where, either the saw frames may be erected near a river, where the heavy ordinary foundation would be very costly, or where, as is often the case, the frames may be employed in a forest, and require to be shifted occasionally to fresh positions. Messrs. Robinson's frame is arranged to cut either logs or deals. For the former work, a central upper pressure roller is employed, the bottom feed roller being driven in the usual manner by gearing worked from the ordinary silent feed. The arrangement for regulating the pressure on the upper roller is peculiar and somewhat complicated. The balance weights are placed outside the frame of the saw, and below the ground level. To the end of the bar carrying each balance weight is attached a vertical connecting rod, which takes hold of one extremity of a horizontal lever, the other end having a pawl which engages into a ratchet wheel mounted on a shaft, and passes through a hole in the horizontal bar just noticed as carrying the pawl at one extremity. The shaft upon which the ratchet wheel is keyed, extends across the front to the centre of the machine, and near the top, having at the outer end a hand wheel, and at the inner end a small pinion, suitable bearings being provided for it in the frame. In the centre of the frame, over each pressure roller, is cast a guide in which a vertical rack is free to move up and down, the lower end being forked to receive the roller. The pinion already mentioned as being on the extremity of the horizontal shaft, engages in the rack of the pressure roller bar. It will thus be seen that the pressure on the log is transmitted through the system of connecting rods and levers to the ratchet wheel and teeth of the rack, and thence to the roller.

The grooved feed wheel is moved by an eccentric on the main shaft at the bottom of the frame, the rod of which is attached to a slotted bar, which communicates motion to the pawl of the feed. The saws are contained in a wrought-iron frame, the bottom of which is connected to a central crank in the middle of the main shaft, while the top works in guides which are formed in the frame of the machine. When it is desired to cut deals instead of logs, the central pressure rollers are raised, and side rollers are lowered by means of hand wheels on the top of the frame; two deals can thus be cut at the same time in the machine.

These semi-portable log and deal frames are made by Messrs. Robinson to cut logs up to a diameter of 30 in. Beyond that size the work is too heavy to trust to the temporary foundations which are sufficient for smaller timber. The one exhibited cut logs 16 in. in diameter, weighed four tons, and required three horse power to drive it.

The band saw exhibited by this firm possesses no special feature; the same remark applies also to the circular saw bench.

The fret saw in this exhibit was a very poor tool compared with Whitney's, already described in a previous page, or by the side of M. Arbey's machines of this class in the French section; indeed none of the English makers showed a good tool of this kind. Robinson's fret saw consists merely of a

table, and standards forming the guides for the saw frame, which is composed of a vertical bar and two horizontal arms, top and bottom, carrying the blade. On one side of this vertical bar and near the toe is a pin, to which is attached the connecting rod, which is driven off a small crank shaft with flywheel and pulley mounted on it. The table can be canted for bevel cutting.

Armstrong's dovetailing machine was the special tool of Messrs. Robinson's exhibits. It possesses no novelty, but excited as much interest at Vienna as it did at the Paris Exhibition of 1867. It is in all respects an excellent and beautifully worked out machine, and the workmanship of this, as of all the other tools at this stand, was very meritorious. Its chief feature consists of two canted discs driven by appropriate gearing. These discs incline towards each other, as shown in fig. 12, Plate 210, so that they are almost in contact at the bottom, and upon these peripheries are placed spiral saw blades, set at the same pitch as the feeding screw of the machine; for a portion of their length the saws have plain surfaces, for the rest, the edges are turned over at right angles to the blade, the width of the turned edge increasing from nothing to the full breadth of the dovetail; the plain portion of the saw blade is fixed in the disc, the bent part is made in short lengths, which are held by set screws, and easily shifted, an operation always necessary when it is desired to cut the pins instead of the dovetails, as it is evident that the cutting edge for the former must be in the reverse direction to that for the latter work. The wood to be cut is fixed on a table, and the edge truly adjusted by a gauge attached to the machine, and the table, being thrown forward, is carried along by a feeding screw until it reaches the saw blades. These, in entering the wood, commence by making a clean cut, but as soon as the bent blade comes into operation, the bottom as well as the side is gradually cut through. By this means a series of dovetail holes are formed, the first saw cutting one side, and the following saw finishing the other. The distance apart of the dovetails corresponds, of course, to the pitch of the feeding screw. When it is desired to increase the number of dovetails from the normal, all that is necessary is to advance the table by means of a screw placed beneath it for that purpose. In this way any desired number of subdivisions can be obtained. If it is wished to form blind dovetails, the table is canted to the necessary angle. The operation for forming the pins is exactly similar, the only difference being, as we said, that the bent portion of the saw blades are turned in the opposite direction.

The mortising machine made by Messrs. Robinson requires a few words of description. It has a fixed table, except for horizontal motion, the whole of the moving parts being brought down to the work, the driving strap taking up the slight variation in length caused by this movement; the chisel is reversed by means of a small collar, to which is pinned a forked lever, the handle of which rests in stops on each side of the spindle. Fig. 13, Plate 209. This detail, which we need scarcely say is not new, is inferior to that in both the Rogers and the Fay mortising machines, and not to be compared to the beautiful device of Richards for the same purpose and adopted by Messrs. Ransome.

The same firm exhibited an irregular moulding machine, consisting of a table with a fixed standard, carrying an arm, which revolves around it, and supporting a headstock, also jointed to the arm, so that a universal movement in a vertical sense is obtained. The pulleys on the standard are coupled to a vertical toolholder in the headstock, so as to turn freely with all movements of this latter; in the headstock is a horizontal feeding screw, actuated by a hand wheel, by which motion is given to the tool. The depth of the cut is regulated by a quick-threaded vertical screw, connected with the cutter bar by a bracket; by turning the screw, the tool can be run up clear from the work, while by adjusting a stop on a small wheel at its lower end, the depth of cut is regulated. At the other end of the table is an ordinary vertical revolving cutter for irregular mouldings; a washer placed below the cutter serves to regulate the depth of cut.

Messrs. Robinson's moulding machine, like all the other tools in his exhibit, was heavy and well made; the four feed rollers are driven off one pinion, set in motion by a worm and bevel gearing; these rollers are hinged

to one common centre, so that they may all have an equal adjustment in accommodating themselves to different thicknesses of timber, the constant pressure they exert being obtained by means of hanging weights. All four sides of the timber are of course cut at the same time, and the distance between the side cutter is regulated by means of a hand wheel at the side. The top cutter slides in bearings, and in one variation the frame holding this cutter is hinged at one side, the object being to facilitate the cutting of canted mouldings. The machine is provided with four-speeded pulleys for different classes of work.

The general joiner of Messrs. Robinson is rather a number of independent tools connected together than a compound machine, and is just the opposite to that of Messrs. Worssam, who runs all his principal tools off one spindle. It comprises a circular saw bench, a moulding machine, a band saw, a tenoning machine, and a boring and mortising tool. The circular saw bench is of course provided with a canting fence, and along the front edge of the table runs a groove for a cross-cutting plate, having attached to it a graduated arm for setting out the widths of the cut. The moulding machine differs but little from that just noticed as an independent tool, and the tenoning arrangement, though good, has no novelty in it. The means for regulating the distance apart of the horizontal cutters is similar to the arrangement found in Rogers' tenoning machine, namely, the two screws working one within the other. When used as a boring or mortising tool the tenoning table may be removed, and the borer placed in the centre of the upper cutter block. The band saw is of much the same pattern as the larger independent machine before alluded to, and has in contact with the back of the blade a small free-running steel roller similar to that seen in the band saw by Fay in the United States section. This detail, as already said, is not to be compared with Whitney's ingenious arrangement for the same purpose, nor with that upon Ransome's band saw, which we shall describe presently. With the exception of one or two sharpening and other accessory tools, we have now described the whole of Messrs. Robinson's exhibits, and will pass on to a consideration of those at an adjoining stand.

Messrs. Samuel Worssam and Co., of Chelsea, exhibited a number of machines, some of which are of a special character. This firm had also a portable log frame of ordinary design. The Worssam feed is worked by an eccentric placed on the main shaft on the side of the machine, opposite to that on which the feed stands, the motion being communicated through a small shaft running in front of the frame, having one end connected with the eccentric rod and the other with a slotted link in which the connecting rod works which moves the feeding pawl. The pressure rollers are placed on each side of the frame, and are affected by ordinary bars and weights which lie in the longitudinal axis of the frame. The swing frame carrying the saws is driven by a pair of connecting rods outside the main frame, the main shaft having of course two cranks.

The trying up machine in this exhibit is intended not only for surfacing and squaring up heavy, but also for planing and moulding, thin timber.

When employed for the latter purpose the pressure rollers are removed, and small rollers take their place. These rollers are so adjusted as to accommodate themselves to any want of truth in the timber, as in preparing thin work too much waste would be sometimes incurred if the wood was absolutely squared up. A step-rack is adopted in the feed of this machine, and the saddle in which the cutters are carried can be moved at will by means of a bevel gearing at the side. The tool can also be converted into a moulding machine by substituting moulded for plain cutters.

The general joiner of Messrs. Worssam and Co. varies widely from that described as exhibited by Messrs. Robinson and Sons. It has at least the merit of being a simple tool, although we consider that efficiency has been sacrificed to attain this. It combines of course all the varied operations of sawing, regular and irregular moulding, tenoning mortising, and boring; and with the exception of the two small horizontal circular saws which are used to cut the shoulders of the tenons, the whole of the tools are mounted on the

same shaft. This is a serious disadvantage, because the saws, the cutters, and the boring tools must all run at the same speed instead of being varied to suit each class of work, and, moreover, when the machine is fully occupied, the men employed upon it must interfere more or less with each other in shifting their work. The moulding apparatus only cuts on the upper surface, so that if the timber has to be planed on more than one side it cannot be worked at this tool. The arrangements for cutting the tenons are peculiar to the machine, and consist of two small circular saws placed parallel to each other, and at a distance apart corresponding to the width of the tenon worked in connexion with two horizontal circular saws, which are employed to cut the shoulders. The wood is fed vertically upon the first pair of saws, after being fixed in a sliding carriage on the upper part of the machine, and a vertical rod with a sliding gauge is attached to the carriage to regulate the work. This method of vertical feed is open to objection when large pieces of timber are being cut. Of course the spindle upon which the saws run can be employed for a variety of purposes, as in all machines of this class, and in the same way the spindles upon which the tenon shoulder saws are mounted can be used for moulding cutters for irregular work.

The saw table is provided with a suitable groove for the cross-cutting plate, and the fence, which can be canted to any angle, is mounted upon two screws on the table upon which it is traversed. Upon the main shaft of the tool is a sliding block, which can be moved by hand into a suitable recess in the top of the frame so as to lock the machine when desired.

Altogether, we do not consider that, as a general joiner, Messrs. Worssam's machine is so efficient or complete as that of Messrs. Robinson's, although of course it is less complicated. The latter maker has attempted too much, the former has done too little.

We have yet to notice two special tools belonging to this exhibit. These are parquetry machines—one for cutting grooves in the blocks, the other for surfacing the squares of glued-up work.

Until very recently the manufacture of parquetry was carried on independently of mechanical aids. About a year ago, however, important progress was made in this direction by Mr. S. W. Worssam. The machines exhibited perform the operations of edging, grooving, and tonguing the separate parts to form a given pattern, and of surfacing the work when the parts are put together. They have a high degree of merit, and are illustrated in the engravings. Fig. 1, Plate 209, represents a side elevation, fig. 2, an end elevation, and fig. 3, a plan of the machine for edging, grooving, and tonguing; whilst figs. 4, 5 and 6, respectively show side and front elevations, and a plan of the surfacing machine.

In the edging machine a single cutter block is used, which is mounted on a rotating spindle, and is fitted with changeable cutters variously formed to suit the work to be done, whether tonguing and edging, or grooving and edging. In connexion with this rotating spindle is a double set of tables, which travel upon guides, so that two operatives may work at the same time at one machine without interfering with each other, the tables being placed one on each side of the cutter. The tables are provided with fences and cramps or holders, so that either a single piece of wood or a made-up square of parquetry can be acted upon by the cutters. The parquetry to be surfaced is taken to the machine shown in Figs. 4, 5, and 6, where it is made fast to a revolving disc, which is fixed to a shaft carried by a headstock in a somewhat similar manner to a lathe mandril. In front of this disc are two cutters mounted on a slide or saddle. One of these cutters is shaped like a gouge, and is used for roughing out the work, whilst the other is a plane iron fixed at an angle, and which follows the gouge, giving the work a perfectly smooth finish. There is a self-acting arrangement for travelling the saddle carrying the tools, which consists of bevel gearing and a reversing clutch acting on a square-threaded screw. Passing along the front of the machine, and connected with the clutch lever, is a rod fitted with stops, against which the

traversing saddle impinges, and by this means throws the clutch in and out of gear, and stops or reverses the saddle.

The chief advantages attending the use of these machines, as against hand labour, are that a greater quantity of work can be turned out in a given time, the work being of better quality, and that it can be produced by unskilled labour at comparatively small cost. These are great advantages in countries like Germany, Austria, and Bohemia, where carpets are seldom used, the floors generally being formed of parquetry. We may add that these machines were by far the best of their class shown at Vienna.

The band saw, and one or two other tools exhibited by Messrs. Worssam, call for no special notice here; but we should allude in passing to the mitring machine shown by them, and which differs only from that of Messrs. Ransome and Co. in the fact that, in the former, the wood is inclined to an angle of 45 deg., and the knife is vertical, and in the latter the work is kept horizontal, and the blade is inclined. There can be no doubt that the Shute machine is by far the better of the two, and it is clear that one machine suggested the idea of the other, but which was the earlier of the two we do not know.

In conclusion, we find in Messrs. Worssam's exhibits, good workmanship, and useful tools of a lighter pattern, and less complication than those of Messrs. Robinson, although the machines of each maker are probably well adapted to the special demands which they supply.

Passing by the stand of Messrs. Powers, James, and Western, where was exhibited a varied collection of tools, which were fair examples of the usual design and workmanship of these exhibitors, but which presented few new features, if any, we arrive at the last of the series, Messrs. Allen Ransome, and Co.'s, who finished also the British section of the Machinery Hall, and who were fortunate enough to have had allotted to them the best position of all the makers of this class of machinery.

Messrs. Ransome arranged their exhibits to greater advantage than the other manufacturers, probably on account of the facilities which the large space afforded them. They, moreover, sent a more complete series of tools, which are for the most part of new design, and contain more or less originality of detail.

They, like the other exhibitors we have named, showed a portable log frame the construction of which is reduced to a very simple form, and which, at the same time, is a highly efficient machine. See Fig. 7, Plate 209. It stands upon the usual light foundations, and has below it a shallow excavation to collect the sawdust, which then falls down an incline to a pit at the side of the machine, whence it can be easily removed. The swing frame contains 15 saws, the greatest number that can be mounted in the size exhibited, for cutting up 14 in. logs. A silent feed motion is adopted, but the pawl is driven not by an eccentric in the usual manner, but by a pin fixed in a slotted quadrant, keyed to the pin of one of the cranks which drive the swing frame. This arrangement is at once simple and effective. Both the feed rollers are driven by gearing from the feed, the wheels being enclosed within the hollow frame of the machine. The upper rollers are pressed down by weights, placed not in the axis of the frame, but at right angles to it, so that they are much more easy of access than in the ordinary arrangement, and can both be controlled by one man simultaneously. The swing frame is worked by a couple of connecting rods, one on each side of the main frame, from the double crank shaft. This machine is well balanced, and runs with comparatively little vibration.

The self-acting circular saw bench was not a new pattern, but was fitted with Ransome's patent automatic feed, which is a very neat arrangement. A four-speed pulley on the main shaft is coupled by a strap to a similar pulley on the forward end of the machine; upon the shaft on which this pulley runs, is a worm working a worm wheel and pinion, which gears into an internal toothed wheel, the outside of which forms a drum for the feeding cord; this cord is led over a small free roller at the end of the frame, and, by means of a hook attached to the extremity, catches hold of the timber to be cut, and draws it against the saw. See Fig. 8, Plate 209.

We now come to the band saw in this exhibit, which has packing boxes for steadying the saw blade above and below the table; this device, while being cheaper, and certainly more simple, than the ingenious arrangement of Mr. Whitney, described by us already, is at the same time a very efficient detail. It consists of a square steel bar, with a circular chamber drilled through it for the greater part of its length; the back of the saw presses against one face of this square bar, in which small perforations are made, communicating with the internal chamber, which is filled with tallow. Whilst the saw runs cold, the tallow of course is unaffected; but the instant the blade heats, small portions of the lubricant melt, and passing through the holes to the back of the blade, insure light and cool running. The blade is confined on each side by blocks of wood bearing against it endways of the grain, but so arranged that the teeth of the saw are left free. The thickness of these blocks is varied with the width of the blade. See Fig. 3, Plate 210.

The mortising machine exhibited in this stand is shown in Fig. 1 and 2, Plate 210. It is designed upon Richards's patent, but modified and improved. The chisel and driving gear are fixtures, the table moving up and down, and being adjustable to any angle for cutting bevelled mortises. The sliding block in which the chisel is mounted, is driven by a connecting rod from a disc on the main spindle at the bottom of the machine, and both connecting rod and disc are concealed within the cast-iron frame. The chisel is designed specially to clear out the cuttings from the mortise at each stroke, and is probably the only efficient self-clearing mortising chisel. It is made with two wings, and is hollow at the back, the inside of the wings being slightly dovetailed. At each cut with this chisel, three pieces of wood are detached, two small pieces by the side wings, and a central piece which slides into the hollow back, and is displaced by the next piece forced in at the following stroke. The action of this chisel is very perfect, and it saves the considerable time required to clean out the mortise when it has been cut with an ordinary chisel. The reversing arrangement of the cutter spindle in this mortiser is an admirable detail in the machine. From a small pulley on the driving spindle at the bottom, a cord passes over two pulleys at the top of the frame and then turning at right angles, goes around a small horizontal grooved disc, keyed upon the cutter spindle The tendency of this cord is of course always to drive the cutter spindle, but this is checked by the introduction of a couple of studs in a groove on the underside of the disc; with one or other of these studs, a vertical rod is always in contact and it is kept up in its place by a spring. The lower end of this rod, which slides in suitable bearings, is provided with a handle; it will thus be seen that so long as the rod presses against the stud in the disc, the latter cannot turn, and the driving cord must slip, but when the rod is depressed by means of the handle, the disc is set free, and commences to revolve; the handle of the rod is, however, instantly liberated by the man working the machine, and the second stud is engaged before a complete revolution can be made. This arrangement was beyond comparison the best of any in the mortising machines exhibited, and the tool altogether was highly satisfactory, both as regards design and workmanship. It combines all the requisites of a good mortising machine; it enters the chisel direct, except with hard woods, for which a boring tool is provided; it cuts a perfect mortise, and clears out the wood. Its ordinary working speed is 600 strokes a minute, and three mortises can be cut with ease in that time.

Adjoining was a hand mortising machine, a well-made and useful tool, Fig. 12, Plate 209, but very imperfect in its action as compared with the one we have just noticed. It has a plain mortising chisel, mounted on a spindle that is coupled by a pair of short links to a long weighted lever, by which the tool is worked. A common reversing motion, like that described as employed in Messrs. Robinson's mortiser, is adopted, Fig. 12, Plate 209; the table which rises and falls, and can besides be inclined to any desired angle, is supported immediately below the chisel, so that the machine works very steadily. The difference between the action of the chisel on this tool, and on the former mortiser, is very remarkable. With the inferior timber available at the Exhibition, it was a matter of very considerable difficulty to clear

out the mortises after they had been made with the ordinary tool, whilst the other clears the hole thoroughly as it is formed.

We must not omit to notice the ingenious and largely used tool known as Shute's mitring machine (see Fig. 16, Plate 210). We have already alluded to this in noticing Messrs. Worssam's exhibits. It is only fair to Messrs. Ransome to state that the tool was exactly copied by Messrs. Zimmermann, of Chemnitz; we are, however, bound to say that this latter manufacturer freely admitted the imitation.

We now come to a class of tools in which Mr. Ransome has made very considerable advance, namely, the high speed machines where revolving cutters are employed, such as tenoning, moulding, planing, and trying-up machines. This is quite a new feature in the construction of this class of mechanism; a short time since a velocity of 3,500 revolutions a minute was the maximum that was obtained in the fastest machine for ordinary joiners' work, but the cutter blocks of some of the tools exhibited by Mr. Ransome have a velocity of 6,000 revolutions per minute, an enormous speed, only to be obtained with safety by the most careful workmanship and judicious design. To make good work with such machines it is especially necessary that they should be well balanced, and without being heavy, should be so rigid as to reduce the vibration as much as possible; the wood which is being operated upon must be fed into the machine with perfect regularity and certainty of movement, and it must, moreover, be held down tight in place close to, and on each side of the cutters. The revolving blocks must be made and balanced with great care, and excepting where they are very short should be supported by bearings at each end. In Mr. Ransome's new high-speeded machines, the spindles of all the cutter blocks are of mild centred cast steel, the bearings are large, and are made self-lubricating. The lower half of the brass is formed with a chamber underneath, and in the bottom of the bearing is a slotted opening leading down into the chamber, and with two more openings in the sides also leading into the same chamber; a piece of felt is introduced in the lower opening, and this being always in the oil, the latter is drawn up by the rapidly revolving shaft, and is then thrown over into the side openings, where it falls back again, and thus circulates constantly.

The foregoing are the chief modifications Messrs. Ransome have made in perfecting these high-speed machines, and the result has been that work is turned out much cleaner and quicker than by tools run at the ordinary rate.

Taking the tenoning machine as the first example of these modifications, we find that its construction is as simple, perhaps more so, than that of any other we have seen, and that the greatest care has been taken to obtain well-balanced, easy running cutters. The feeding table is light and strong, and runs upon friction pulleys and planed guides. Figs. 10, 11, Plate 209. The wood to be cut is laid upon the table, the bar of which next to the cutters is fixed, the other one, however, sliding, so that its position may be regulated. A pressure bar, hinged at the back of the table, and clamped upon the wood by a hand wheel in front, keeps the work down in place. In the sliding bar just mentioned a parallel slot is cut for nearly its whole length, and in this is placed a light spring supporting a strip of iron which just fits the slot; when there is no pressure upon this strip, the spring has sufficient strength to raise it about one eighth of an inch above the level of the bar. When a piece of wood (or a number of pieces, because in this machine as many tenons as the table will hold may be cut at once) is laid on the table to have the first tenon cut, its weight presses down the bar, but when the piece is turned to cut the tenon at the other end, the shoulder of the first cut tenon is placed so as to bear against the slight projection made by the lifted strip. In this way a number of tenons may be cut without the trouble of setting them out, because the bar acts as a gauge, and keeps them of exactly uniform length between the shoulders. The top and bottom tenon cutters are arranged in the usual way, and the distance between them is regulated by means of two hand wheels, the upper one of which raises both cutters together, and the lower one alters the distance between them. For cutting double tenons, and for scribing the shoulders, a cutter mounted

on a vertical shaft is employed, and is placed a little in advance of the horizontal cutters. By adjusting the relative positions of all these blocks, tenons of any size, depth, or irregularity of shoulder can be produced.

Turning next to the planing and moulding machines, we find that two sizes of these tools were exhibited, which differ from each other in size rather than in any important detail. The same principles we have mentioned as applicable to all classes of high-speed wood-working machinery have been carried out in these machines with great success. Four feed rollers, of which the upper one of the first pair is fluted, and the rest smooth, are employed, and all are driven by suitable gearing from a four-speed pulley in order that the rate of feed may be easily adjusted. On the feeding table is placed a fixed guide for the timber, and a small vertical roller working in a transverse slot against a spring, serves to complete the guide. A pressure bar of wood standing at an angle with the table, and held down by a weighted lever, is placed just in front of the first and upper cutter block. Between this and the pair of side cutters is a bridge pressure bar, which is regulated by a pair of vertical screws, working in brackets cast on the frame, a similar pair being provided to produce the pressure over the bottom cutter, which is at the extreme end of the machine. That part of the table which projects beyond the bottom cutter is hinged, so that it can be thrown back, and the knives be readily got at for sharpening, &c. See Fig. 9, Plate 209.

At present Messrs. Ransome manufacture five sizes of these machines. Of the two that were in the Exhibition, the larger will take stuff 12 in. by 4 in., and the smaller 7 in. by 3 in.

Of a similar class is the panel planing machine, (fig. 6, Plate 210), which planes thin stuff up to 24 in. in width, and 2 in. thick, but on one side only. Four weighted rollers are employed in this machine, and the wood is besides held secure by means of two triangular bars placed on each side of the cutter block, and the pressure of which is regulated by means of small wheels on top of the machine. The trying-up machine is a well-made tool, possessing the special details peculiar to all of Messrs. Ransome's high-speed machines, and having an excellent feed motion consisting of a worm wheel working in suitable teeth on the under side of the travelling bed. Another excellent feature is that the rate of feed can be varied at will when the work is passing through the machine. See fig. 11, Plate 210.

The general joiner of Messrs. Ransome, Figs. 4 and 5, Plate 210, differs widely from that of either Robinson or Worssam, it being more simply arranged than the former, and more efficient than the latter. The circular saw bench has no special feature to notice excepting that the fence is hinged to the edge of the table, and can be thrown back out of the way when the space is required for cross cutting. In the moulding apparatus the arrangement is compact, and the feed rollers are driven by a right and left-hand worm on a vertical shaft, which is worked from below by gearing. All four sides of the timber are cut at one operation, as in the larger and independent machine. Immediately behind the top cutter there is a weighted pressure bar, and in front a bridge pressure block; while a third is attached to a bracket on the frames over the bottom cutter block. In this machine the side cutters are placed last in the series for the sake of convenience, as the plate in which they slide is made available for securing one of the same cutter blocks, and its vertical spindles, when double or scribed tenons have to be cut. The size of timber that can be planed or moulded by this machine is 9 in. by 4 in., and the speed at which the cutters are run is 4,500 revolutions a minute, whereas the saw is only driven at 1,800 revolutions. The tenoning arrangement is precisely similar to the larger tenoning machine already described.

Three other tools remain to be noticed, the universal planing and boring machine, figs. 9 and 10, Plate 210, the combined planing, shaping, chamfering, and mortising machine, and the apparatus for sharpening saw blades, figs. 7 and 8, Plate 210. The first-named of these consist of a table, to which is

bolted a standard, with a long projecting arm, carrying a headstock and revolving cutter, that can be traversed by a screw and hand wheel, immediately below the cutting spindle, and passing through a circular opening in the table is a spindle with a small stud attached to it, and projecting slightly above the level of the table. If desired, this stud may be removed, and a revolving cutter substituted for irregular moulding work. When the tool is operated, a template is attached to the underside of the work, and with the small projecting stud before mentioned, the outlines of the pattern on the template are traced, the revolving cutter, of course, clearing out a corresponding figure on the upper side. Different forms and sizes of cutters have to be employed according to the nature of work done.

The universal planing and mortising machine is a very useful little tool, consisting of a plane cutter block, mounted on the same spindle as a boring tool, which can be employed for round-ended mortises. Over the cutter is hinged a table, upon which the work is guided, or the table may be thrown off, and in its place two round saddles mounted for planing up curved work, the work to be cut, being mounted on suitable templates, which rest upon the saddles just mentioned. Circular angular brackets are also employed for doing chamfered work. Of course moulded cutters instead of plain ones may be used and provision is made for running a small circular saw for light work.

The saw-sharpening apparatus has no novelty except that the stones employed are the so-called Bessemer emery wheels of Mr. Frederick Ransome, and which answer the purpose extremely well. See figs. 13, 14, 15, Plate 210.

We have now taken our readers through the wood-working exhibits of the British section, and in trying to arrive at conclusions as to the respective merits of these exhibits, we find it somewhat an invidious task to give a preference to one maker over another. Still we cannot but observe that excellent as the machines of other makers were, those sent by Messrs. Ransome and Co. had qualities which placed them beyond competition as far as the other exhibits were concerned. Besides the fact that the general style and appearance of the tools are somewhat better than those of the other makers, there are several great and decided advantages introduced by Messrs. Ransome. The arrangement of their machines is, in all cases, of a simple character, the cutters are run at a higher speed than has before been accomplished, and all the improvements in detail necessary to accomplish this with success have been well carried out; the tools are all specially arranged to run with the shafting and placing belts below the floor level, and they have adopted, and exhibited in connexion with the panel-planing machine, the pneumatic conducting apparatus, for carrying off the dust and shavings as they are produced at the cutters.

That an accumulation of shavings and sawdust in a workshop is both inconvenient and dangerous no one will deny, and that the periodical removal of these waste materials by hand is a source of constant and considerable expense, every one owning a shop where working in wood is carried on, knows. It, therefore, follows that any mechanical arrangement for removing these objections would prove a boon to those whom such objections affect. It will be satisfactory then to know that by Messrs. Ransome's arrangement a remedy for the evil is found, and that it is, moreover, one of a very simple and comparatively inexpensive character. It consists in the use of an induction fan, a sufficient vacuum being maintained to withdraw the heaviest shavings and sawdust, which are sucked through pipes and expelled under pressure in any required direction. The principle has been carried out successfully in many shops in America, and has been introduced into England at the works of Messrs. Peto Brothers, Gillingham-street, Pimlico, and at other places. Plate 211 shows the manner in which it is fitted up at Messrs. Peto's establishment, the exhibit at Vienna being necessarily a more limited application. The Plate represents a sectional view of the sawing and planing mills, with the joinery shop over them, in which the apparatus has been fitted.

Taking the lower room first, we have a vertical timber frame and two saw benches, beneath each of which is a funnel-shaped receptacle into which the sawdust falls. Each of these funnels is connected at the lower end with a 5 in. pipe leading to a 20 in. fan driven by a belt from a pulley on the main driving shaft of the mill at the rate of 1,800 revolutions per minute. From the fan another 5 in. pipe is carried into a magazine or store, the sawdust being drawn from the machines by the fan and propelled onwards to its destination. At the right hand end of the lower room are a planing and a moulding machine and a joiner, which are fitted with hoods attached to 5 in. vertical pipes arranged to work telescopically, so that the hoods can be raised or lowered as required, in order to get at the cutters. These vertical pipes open into a 10 in. main above them, through which the shavings are drawn by means of a 30-inch fan driven at 1,100 revolutions per minute. From the fan the shavings are blown down another tube into a fire-proof room near the boiler house, and they are consumed under the boilers. In the floor of the joiners' room are several covered shoots communicating with the 10-in. main pipe, and down which the shavings are swept and are drawn off by the 30 in. fan and delivered into the fire-proof room.

The invention, as already observed, is of American origin, although as carried out at Messrs. Peto's works it has been much improved by Messrs. Ransome. The chief point to which attention has been given is the fan, which has been greatly strengthened and simplified. This system of clearing shops possesses several undoubted advantages as compared with the employment of manual labour. It does away with the nuisance of being compelled to keep labourers about the works for the special purpose of clearing them of waste, and it, moreover, enables the shavings and sawdust to be kept separate and clean, which is very desirable where they are utilised, as they not unfrequently are, especially sawdust. The atmosphere, as well as the floors, is kept free from dust, a point of importance to workmen in many instances. It ought also to effect a saving in the item of insurance, because companies would probably accept lower rates of premium in consideration of reduced risks. The principle answers perfectly and in view of the advantages it possesses we have no doubt of its speedy adoption in works of this class generally.

In concluding this article we may repeat that there was no other series of wood-working machines in the Exhibition so complete, and possessing so many novelties in detail, as that of Messrs. A. Ransome and Co. of Chelsea, and the conspicuous place they obtained in the Machinery Hall was thoroughly well merited.

France.

The exhibits of machinery for wood-working contained in the British sections and just described were, taken as a whole, very superior to the displays of a similar nature made by any other country. As we shall see further on, both Germany and Austria showed a great variety of very excellent wood-working machines, some of the best, however, being copied direct from or having been suggested by English and American originals.

The French section was decidedly poor in exhibits of this class, although some of the leading makers were represented, but there was little originality of design, and apparently but small progress had been made since the Paris Exhibition of 1867. The machines looked clumsy besides those that were close by, Messrs. Ransome's, Worssam's, and Robinson's. At the same time there were some small special tools in the French section, better than any of the same class to be seen in the English department. Thus in the latter there was not one really good fret saw shown, whilst there were a number in the French section, far cheaper, and, though not so well designed as Mr. Whitney's in the United States department, still highly efficient tools.

M. F. Arbey, of Paris, contributed the largest and most complete collection of any of the French maker. M. Arbey holds deservedly a leading position among the makers of this class of machinery in France, and he showed several good designs, good workmanship throughout, and, comparatively speaking, great cheapness. On the other hand, the larger machines

had undue heaviness of parts, and a lack in perfection of detail, nor were they adapted to run at such high speeds as Messrs. Ransome and Co.'s machines. The portable leg frame was entirely unrepresented, and probably is not yet made by any French manufacturer, while the fixed frames of M. Arbey, as well as those of other makers were not a little clumsy. M. Arbey showed several good examples of band and fret saws, the latter meriting very high commendation. The larger of the band saws possessed no detail worthy of special notice, but the two smaller ones were good, and well adapted to small works, where no steam power is available. Both machines have wooden frames, and the heavier of the two is worked by hand through a large spur wheel gearing into a pinion on the lower pulley shaft. This tool was extremely well made, and the price was very low. The second machine was very similar, but considerably lighter, being driven by the foot. It had a combined frame, the lower part being of wood, and the standards carrying the upper pulley of cast iron. It was provided, moreover, with a working table mounted on quadrants, so that it may be inclined to any angle to suit the work. Power is communicated through the pedal to a crank shaft and gearing, the lower pulley being mounted on a second shaft. Of course this machine can only be employed for very light work.

In connection with the saws, there was shown a neat apparatus for setting and adjusting saw bands. It consists of a wooden table, on which are mounted horizontally two wheels, corresponding to the upper and lower pulleys of the band saw. The axis of one of these wheels is adjustable, and the distance between it and the fixed wheel may be increased or diminished at will. On the side of the table is placed a vice, between the jaws of which the saw band which is passed over the two horizontal wheels is fixed while it is being set.

One of the most conspicuous machines in M. Arbey's collection was a large planing machine of very heavy parts, and containing one detail which is said to be well received in France, but which we think makers are not likely to adopt here. The top cutter, instead of being of the ordinary form, that is to say, of a block with four suitable projections to receive the plane knives, consisted of a large cast-iron block, with a spiral edge, to which is secured the cutting blade formed of a thin strip of steel, and sprung into position, so that it produces a continuous cutting face for its whole length. A peculiarity of this machine is the mode by which the cutter is sharpened. The cast-iron block is mounted in slots in a pair of standard brackets, and it can be raised or lowered according to the thickness of the timber to be planed. When it is desired to sharpen the blade the block is raised to the upper part of the brackets, and the strip of steel is subjected to the action of a small emery disc mounted on a spindle, and driven at a high velocity. This disc travels along the spindle so as to reach from end to end of the blade, which is always kept in contact with it. This is certainly the simplest mode in which the sharpening of the cutter could be effected, but the efficiency of the whole arrangement is doubtful, and will scarcely be copied in this country. The remainder of M. Arbey's exhibits need no notice, as they contained little or nothing of novelty.

MM. Perin, Panhard, and Co., of Paris, occupied considerable space with their wood-working machinery, but they were not equal to M. Arbey either in design or workmanship. A conspicuous object was a trying-up machine of antique pattern, and which while occupying to the full as much space as the similar machines of Messrs. Ransome & Co., or Messrs. Worssam, could not deal with nearly such large scantlings. The timber to be faced is secured to a long moving table driven from below by a rack, the means of attachment consisting of a large number of sliding clamps moving in grooves in the table, and adjusted each by means of a screwed rod, terminating in a small hand wheel. The cutting edges are six in number, three being chisel and three gouge pointed, and fixed at suitable angles in a large horizontal disc running on a vertical shaft supported in bearings above and below. These bearings, and with them the horizontal disc, can be moved up or down in guides formed on the main vertical frame, in order to work different thick-

nesses of timber. It will be seen at once that in such a machine as this either timbers of only comparatively small width can be faced, or else that the machine must be made of very great size, because as the shaft carrying the cutter disc passes through it, and has a lower as well as an upper bearing, less than half the diameter of the disc represents the width available. Hence the table is unduly narrow, and the whole machine appears out of proportion.

The same firm showed a small panel planing machine with top-cutter, and smooth pressure rollers, driven by gearing and a chain. The quantity of work that could be turned out by this machine must be very small, and it could not run at anything like the high speeds of the English machines, so that the work produced would not be so good. The same remarks apply with even greater force to a moulding machine of very poor design, made to cut on one side only. An endless chain feed is adopted in this machine, and a system of pressure levers and weights hold the wood down upon the table, which rollers are introduced to keep the wood up against the cutters.

MM. Perin and Co. also exhibited a very heavy boring and mortising machine with a rising and falling table, and the mortice bar worked by a connecting rod and pin in a slotted disc. There was besides a small horizontal boring and mortising machine in which a pulley was mounted upon the drill spindle, and the latter driven direct by a belt off the main pulley below. The mortiser was placed alongside the drill spindle, and had a reciprocating motion in guides upon the frame. It was actuated by hand, by means of a long lever and balance weight. The wood was placed on a table which could be raised, lowered, or advanced at will, and was held in place by a screw and flat-footed pressure stud, which kept it firmly against the guiding block at the side of the table. No comparison could be made between this machine and the little hand mortiser of Messrs. Ransome & Co., which was at once far better designed and executed, much smaller, and lower in price.

MM. Perin and Co. made of course a large display of the saw bands for which they are so justly noted, and there were a number of band saws of different sizes. One of these attracted considerable attention from its large proportions. It was, in fact, the most stupendous machine of its class in the exhibition. It was made for cutting large logs of timber, and could take in trees of almost any girth and length, with the aid of auxiliary carriages. The horizontal frame is of great length, and carries a series of spindles, each of which has mounted upon it three rollers, upon which runs the table for carrying the timber. This table is of necessity divided into two parts throughout its whole length to allow for the passage of the saw blade. The work is very good in this machine, but we do not consider that a band saw can be applied with advantage for such a purpose as cutting up logs, and it compares very disadvantageously with the German and Austrian log frames, which will be hereafter described. In a common log frame the costly and cumbrous table forming part of MM. Perin's machine is not required, and the vertical saw frame is but little heavier than that in the machine under notice. Lightness and ease of transport are essential features in the design of a log frame, which often has to be erected in the middle of forests, and in localities far removed from any ordinary means of transport, and which has, too, to be frequently shifted from place to place, as the distance grows too great for carrying the timber to the saw.

An interesting machine by the same firm is the band saw for cutting up planks or veneers. There was no corresponding machine in the English section, although they were to be found both in the German and Austrian departments. The machine is a large and heavy one, and carries upon the table the sets of vertical guiding and driving rollers through which the timber passes. There are two pairs of these rollers, one pair fluted and the other plain. Both sets are mounted on sliding plates, which can be moved by a screw so as to regulate the distance between them, according to the thickness of the work. The fluted rollers are moved by suitable gearing, driven off a pulley on the lower pulley axle. Extremely good work was done with this machine, which was altogether an excellent example, and one of the best features of MM. Perin's exhibits. A smaller machine of the same class

also deserves notice. It, too, is intended for cutting planks and veneers. In this tool a broad flat plate is employed instead of the smooth rollers. This position of this plate may be adjusted to suit the thickness of timber, by means of a pair of parallel bars worked from the side of the machine, and moving the plate to and fro. In front is a single vertical roller, kept up to its work by a balance weight.

M. E. Baras, of Paris, exhibited several machines, to a notice of which a few lines may be given. The collection comprised a band saw of fair work, but of no special merit, and a circular saw bench, of which the same remark may be made. A universal moulding machine showed some originality of design, but will scarcely be copied. It was furnished with revolving cutters on vertical spindles, and the timber being worked, rested against adjustable guides, whilst a bracket, also adjustable by means of set screws passing through slots in the table, carried at the end which overhung the timber a flat spring, at each extremity of which was a roller, which exerted considerable pressure upon the timber. A boring and mortising machine like Perin's, but smaller, and not so well made, completed M. Baras's collection of wood-working machinery, which, however, only formed a small portion of his exhibit of machine tools.

To M. Guillet of Auxerre (Yonne) is due considerable credit for the wood-working tools he exhibited, which showed quite as good work and more originality than any other collection of the same class in the French section. This maker showed no saw frames, but the most conspicuous feature was a small trying-up machine, which did excellent work, although rather slowly. It consists of a long vertical cast-iron frame, from the centre of which a short frame projects at right angles. This frame is of necessity very heavy, as it carries the moving vertical table to which the timber is attached by means of clamps and screws. The movement is mounted on the short frame just mentioned. This frame carries suitable bearings for a horizontal shaft with fast and loose pulleys, while on the end towards the vertical moving table is mounted a large disc with three cutters, which operate on the timber in the usual manner. Along the back of the table is placed a rack into which gears a pinion, moved by a hand lever, and suitable gearing placed on the short frame in the front of the machine. There was no other machine of this type in the exhibition.

There was also a small circular moulding machine of the ordinary character, with a rapidly revolving cutter mounted on a vertical spindle, and projecting above the table, on which the work is placed. A number of moulded cutters of excellent workmanship were shown with this machine. A special tool for turning the hubs of wheels, table legs, &c. should be mentioned as a novelty. It is a small machine, consisting of a heavy cast-iron frame and horizontal main shaft, with suitable fast and loose pulleys at one end, and in the middle, arms keyed to the shaft, for carrying the moulded cutters, the form of which corresponds to the contour of the work to be done. In cutting wheel hubs the wood revolves against a fixed cutter, but for the moulded legs of tables, pillars, &c. the wood is fixed, and the cutters revolve, striking the wood with each revolution, until the face presented to the tool has been cut into shape. The wood is then turned, so as to present another face to the tool, and so on. It is obvious that the faces thus moulded are not flat, but curved, the curve being of course identical with the revolving path of the cutters. This machine did extremely good work, and possesses considerable merit for its ingenuity.

Sweden.

As may be expected, wood working machinery occupied a fair share of the space allotted to Sweden in the machinery hall. The finished timber trade has reached such large dimensions in that country, that makers of such machinery find ample occupation, while a large quantity is exported from England. The work of the Swedish manufacturers as shown at Vienna is excellent, but the designs do not compare favourably with those of English

makers. They have an obsolete aspect, and are probably descended from old English stock. Timber framing and multiplicity of parts prevail, but at the same time the work performed by the machines is excellent, although they cannot deliver at a very high rate, and are not adapted for such speeds as are now common here.

There were three Swedish exhibitors coming within the present section, of whom the chief were Messrs. W. Gibson and Sons, of Göteburg. The exhibits of the first of these makers to be mentioned was a large four-sided planing machine, with iron frame. Without drawings it is rather difficult to convey a correct idea of this machine. From end to end, from each side of the frame standards rose at short intervals, of different forms to carry the pressure bars, rollers, &c. At the feeding end of the machine were two pair of fluted rollers of large diameter, and immediately in advance, another pair of standards containing the bearings for the spindles of a large plain roller. Then follows a small cast-iron carriage, mounted on four smooth rollers, running upon the timber as it is fed in. Upon the top of this carriage rest the ends of two square bars, the other ends of which are placed in sockets carried on a shaft, the ends entering square blocks placed in the vertical slots of another pair of standards, the space between the top of each block and the upper side of the slot being occupied with spiral springs to throw a pressure on the spindle, and so through the sockets to the bars above mentioned, and the carriage with its four rollers. But on the same spindle were two other cast-iron sockets, with square holes at a different angle however with reference to the timber being worked. Through these holes pass square bars, with the lower ends forked to carry each a small roller for pressing against the timber. It will of course be understood that this pair of rollers does duty on one side of the spindle, and the carriage before mentioned on the other. Three fixed knives are set at an angle to take a shaving from the under side of the timber immediately below the carriage, which is provided for the purpose of pressing down the timber upon the knives. Then follow two fixed knives to act on the edges of the timber. One of these knives is fixed, and the other is adjustable to suit the width of the work, and close by are the side revolving cutters with brass knife blocks.

We now come to the top cutter in an inclined headstock. The pulley by which the cutter spindle is driven is placed to one side of the machine within the headstock frame, which is widened out for the purpose, and the cutter block can be raised or lowered in the ordinary way. Finally, in front of the headstock are two more standards, one on each side of the frame, within slots in which spiral springs are placed bearing upon the ends of a transverse rod, which carries sockets similar to those before mentioned, two of which receive bars carrying each a small pressure roller, and the other are connected with a large smooth roller, the position corresponding with the bottom cutter. At the delivery, a suitable platform is provided to receive the timber.

Messrs. Gibson and Co. had also a large moulding machine with timber frame of a somewhat similar design to that just described. This also cuts on all four sides, and is provided with a number of smooth and fluted rollers arranged in pairs, and mounted on spindles, with blocks mounted on the ends, upon the top of which rest the extremities of plate springs, by means of which the pressure upon the timber can be regulated with a set screw. A long flat spring also with a set screw bearing upon the centre exert a pressure variable at will upon the side of the timber. There is also provided a plain or moulded wooden or iron block, and pressed upon by the end of a spring, bears on the upper face of the timber. Finally, at the end of the machine is a long curved spring pressing against the opposite side of the timber. The cutter blocks like those in the iron framed machine, are of brass. There was besides a small moulding machine, cutting on one side only. The frame of this machine is also of timber, and the table is placed at the side, the cutter spindle overhanging the side and being driven by a pulley on the spindle in the middle of the frame. There are a pair of fluted rollers running in a small cast-iron saddle, on the top of which a flat spring presses,

adjusted by a set screw. A small tenoning machine with a timber frame completed the collection of Messrs. W. Gibson and Co.

Messrs. J. and J. C. Bolinder, of Stockholm, exhibited a very good double circular saw with one fixed blade, the other sliding on the same shaft, and with it an iron table placed to the outer side of the movable saw. This table moves in guides parallel to the saw spindle, and is actuated by means of a long lever and graduated quadrant. At each end of the machine, is a pair of smooth rollers, the bottom one of each pair being fixed, and the top ones rising and falling, their bearings sliding in vertical slots in the frame. The position of the rollers is regulated by means of a foot lever placed at the side of the machine. The bottom rollers are driven by suitable gearing.

Finally, amongst the Swedish exhibits of this class we may mention a set of three machines for cutting cork. They are the design of Mr. Emil Boethins of Stockholm, and are worthy of illustration and minute description. As, however, illustrating these machines would prejudice the English patents Mr. Boethins is about to obtain, we must be content to place the fact on record that the set of tools was shown in operation at Vienna.

Austria.

The exhibits of wood-working machinery by Austrian makers were very numerous, and proved that this special branch of manufacture is well developed in that country, far more advanced indeed than in France. Messrs. Pfaff, Fernau and Co. of Vienna exhibited largely, and may first be noticed, the tools they exhibited of this class being as follows.

A large double circular saw of a somewhat novel arrangement. The large rectangular table of this machine has an opening in the middle and is provided with four bearings, two at the outer edges of the table, and two at the edges of the opening in the table. These bearings are all in line, and carry two spindles, on the inner ends of which are mounted the two circular saws, while on the outer ends are pulleys by which the saws are driven. Two standards are cast upon the frame, formed with slots in which the bearing of a large grooved roller slide, and are raised and lowered by means of screws and hand wheels on the top of the standards. The driving rollers below are provided with suitable gearing, and driven by a worm wheel and worm on one end of a shaft, while at the other is a large disc, slightly coned on the inner face which is covered with leather, and is driven by a small cone which can be moved up and down upon its shaft, and its position relative to the centre of the disc varied so as to regulate the speed of feed. The disc itself can be moved to and fro upon a key on its shaft, so as to throw it in or out of gear.

A large moulding machine with a heavy frame, formed at one end with a pair of long projecting brackets carrying a shaft and several pulleys, the end ones being a fast and loose pair for driving the machine. The head-stock carrying the top cutter extends across the whole width of the machine and is formed with an inclined face; the cutter block can be raised and lowered, by means of screws and hand wheels. On each side of the head-stock are placed weighted pressure bars, bearing upon the timber. The side cutters are placed in gaps in the frame, being carried in brackets, which slide between cheeks, so that the width between the cutters can be regulated and they are locked easily by adjusting nuts. In front are two brackets supporting springs which press upon the top of the wood, and below these are placed the bottom cutters. Finally come the pressure rollers at the feeding end of the machine. There are four of these, a pair of fluted ones at the top, and a pair of smooth ones at the bottom. The bottom pair are mounted in excentric blocks, by turning which the height of the rollers with reference to the frame can be adjusted, whilst the top pair are hung in bearings at the ends of levers connected with a central transverse shaft, and from the ends of the levers depend vertical rods supporting at their lower ends a table underneath the frame. This table is weighted at pleasure to regulate the pressure exerted by the upper pair of rollers on the timber.

The rollers are driven by gearing at the side of the machine, actuated from one of the pulleys at the end of the frame, already mentioned.

Messrs. Pfaff, Fernau and Co. also exhibited a well made band saw, which presented nothing worth noting, and a drilling and mortising machine which was a very imperfect tool, one mortice a minute appearing to be the average rate at which the work could be turned out by it.

The Maschinen und Waggon-fabriks-actien-gesellschaft, formerly H. D. Schmid of Simmering exhibited a large and well made four-sided moulding machine shown in figs. 1, 2, and 3 of Plate 212. It will be seen that the group of four feeding rollers placed at one end of the machine are arranged alternately, one being fluted and the adjacent one plain. Only the top pair is driven in the manner shown in the drawings. At the delivery end is a transverse shaft with a fast and loose pulley at one end. As will be seen, the machine can be thrown in and out of motion by the operator at the feeding end, a long rod extending the whole length of the machine being provided for the purpose. The pulley at the other end of the shaft drives a small pulley having a pinion on the same shaft, and driving a large spur wheel. A pinion on the shaft of this latter, gears into a second spur wheel, which transmits motion through gearing, as shown, to the top pair of feeding rollers. It will be noticed that these rollers run in bearings placed at the ends of levers connected with a transverse shaft, and that, as described in Messrs. Pfaff's machine, a vertical rod goes down from the end of each of these levers to a table underneath the frame, by weighting which any desired pressure can be brought to bear upon the timber. The bottom pair of rollers are mounted with excentric spindles, also like those in the machine last described, and their relative position can be regulated by means of two worms on one shaft, and gearing into two worm wheels placed on the ends of the spindles. Immediately in front of the feed rollers is placed the bottom cutter block, as seen in the plan and side elevation, while above the cutter is a shaft resting in bearings bolted to the top of the frame and carrying two plate springs for pressing against the top of the timber. At one end of this shaft is a lever weighted as shown. The arrangement of side and top cutters, pressure rollers, &c. is very clearly indicated in the drawings.

A large number of log frames were exhibited by different makers, of which the type is shown in figs. 1, 2, 3, 4 and 5, Plate 213.

The form which has recently been introduced in this country by the principal makers of wood-working machinery, under the name of the portable log frame, is as yet unknown as an article of manufacture in Austria, and, as will be seen from the engravings mentioned above, the log frame is mounted upon heavy foundations. The machine consists of two pairs of standards, placed far enough apart to admit of the saw blades being carried between them. Near the bottom of these standards a shaft runs in suitable bearings, carrying a fast and loose pulley, from which motion is transferred to the pairs of cranks at the ends of the shaft, from which connecting rods ascend, and take hold of the crosshead to which the upper ends of the blades are fastened. This, as well as the corresponding lower crosshead, slides in suitable guides formed in the vertical standards, as shown in the section fig. 2, Plate 213.

The same view also shows the position of the four serrated rollers, between which the timber is fed into the saws, and all of which are driven, a speciality in these continental log frames. It will be seen that the lower pair of rollers run in fixed bearings, and the shafts on which they are mounted, carry at one end, spur wheels gearing into a common pinion fast on the silent feed wheel shaft. Motion to this is given in the mode shown in the side elevation of the machine, from a pair of levers connected with the top crosshead of one of the side connecting rods. A means of adjusting the rate of feed is provided in the screw and regulating hand wheel. The opposite end of each of the lower feed rollers, carries a bevel wheel that gears into a corresponding pinion mounted on a vertical shaft, the upper part of which is provided with a keyway, in which slides a block carrying a similar pinion gearing into a bevel

wheel on the end of the shaft of the upper feed roller. It will thus be evident that in whatever position this lathe may be, it will be always driven from the lower roller. As will be seen from the side elevation and section, these upper rollers have bearings that slide in suitable openings in the frame, and they are also attached to brackets carrying small toothed wheels engaging in vertical racks bolted to the frames. By means of suitable gearing on one side of the machine, the upper rollers may be raised or lowered to any desired position, and detents are provided to hold them at any point.

Amongst exhibitors of this type of log frame, we may mention in the Austrian section, the Archduke Albrecht's Brückenbau and Machinenbau Anstalt, and Ustron, Upper Silesia, the Prague Maschinenbau Actien Gesellschaft Prague, and Mr. G. Topham of Vienna. This latter exhibitor showed also a parquetry machine for facing and tonguing and grooving the pieces; the timber was fed under rollers upon which pressure was exerted by plate springs. The same maker also had a small hand worked trying-up machine, in which the disc carrying the cutters were placed at the end of a shaft, about midway of the frame, this shaft being carried in bearings on cast-iron standards; between the standards was the driving pulley mounted on the same shaft as the disc. The wood was clamped down upon a table sliding in grooves on the frame, the feed being regulated entirely by hand. A parquetry tonguing and grooving machine and a heavy band saw completed the list of Mr. Topham's exhibits of wood-working machinery.

Mr. M. Hopherr of Vienna exhibited a circular saw and a drilling machine both of good design and workmanship. He had also a small moulding machine of considerable merit. It had a wooden frame, and the table was placed at the side of the machine. One top cutter was employed driven by a pulley placed in the middle of the spindle. There were two pairs of rollers, one fluted for the feed, and one plain pair for delivery. The table at the side could be raised or lowered at will.

Mr. Ferd. Tucher of Vienna exhibited several wood-working machines, including a log frame of the type already described and illustrated, and a small fret saw of no special merit in design. He had also a tenoning machine quite after Worssam's pattern, with the vertical and horizontal saws fully described in the English section, a small moulding machine with side tables, like Mr. Hopherr's just mentioned, a small universal shaping machine, and a mortising and drilling machine, horizontal and very heavy, of the same type as one we shall notice presently in the German department, but certainly better in its design.

Messrs. Ganz and Co., of Buda, in Hungary, exhibited a novel arrangement of planing machine for trueing up, and facing timber employed in the manufacture of parquetry. It was constructed some years ago for Messrs. T. Neuschloss and Co., of Pesth, and was used by them until they lent it for the purpose of exhibition. It will be seen from figs. 1, 2, Plate 214, that the machine consists of a large circular and revolving table, to which motion is imparted by means of an interior rack and pinion. Outside the table is a second circular rack, horizontal, however, instead of vertical. In the table are formed a number of slots, arranged in groups of five. The ends of these slots are not concentric with the table, but are parallel to raised blocks formed round the table. Altogether there are eight groups of slots and eight corresponding raised blocks. Sliding to and fro in the slots are pins, which cannot fall on account of the nuts holding them up, as shown in the plan.

These nuts are not rectangular, but of such a form that their inner and outer sides are parallel with the faces of the raised blocks before mentioned. The pins are mounted on horizontal screws, which can be turned by means of the small hand wheels, shown in the illustration. By this arrangement, pieces of wood can be held securely in place as indicated, irregularity of form or width being of no moment, as each pin can be screwed up until its nut takes a bearing. At opposite sides of the circular table is a fast-revolving cutting tool driven by a small pulley, as shown in the drawings. The operation of the machine will now be understood. As the table revolves, pieces of

wood are dropped upon it, and screwed up firm; they are then carried under the influence of the cutters, faced, and taken off the machine by a workman on the opposite side. It will thus be seen that the machine is in reality a trying-up machine, which faces up the wood, instead of leaving it out of truth. No doubt it answers its purpose very well, but much ingenuity and expense appear to be incurred in order to gain a simple end, and no better work could certainly be turned out here than is done by Messrs. Worssam's machinery for making parquetry.

Figs. 3, 4, 5, 6, Plate 214, shows a second machine of the same maker, designed for a similar purpose, but in all respects more worthy of commendation than that previously noticed. It consists, as will be seen, of a long table, supported at each end by a frame, which carries the driving mechanism. A broad groove extends from end to end of the table (see fig. 5), and on each side, strips are fastened, overhanging the edges of the groove, to form a suitable guide for the travelling table, on which the wood is placed. This table is formed of an endless chain, made up of blocks, of the section seen in Fig. 5. In the side elevation, Fig. 3, the arrangement of the whole chain is shown, and the manner in which the blocks are jointed together. At each end of the machine the chain table passes over suitable wheels, as shown in the drawings, and these being driven from the main shaft, a constant motion is imparted to the chain. It will be seen that a number of small points project from the top surface of each of the blocks. These are for holding the wood placed upon them, securely in position. Upon the main table, and near the feeding end of the machines are bolted two long guides (Figs. 3 and 4), parallel to the moving table, which occupies a central position between them. The object of these guides is to insure the wood being placed true on the travelling table, and also to regulate the maximum width of wood laid on. In Figs. 3 and 4 will be seen a double saddle frame placed on the top of the main table, in which are mounted the cutters. At the forward end of the saddle there is placed on a spindle a pressure block carrying two free-running rollers; next come a pair of circular saws to cut the wood fed in upon the travelling table to an exact width. These saws run on a spindle, on the end of which, outside the frame, is a pulley driven off the main pulley at the extremity of the machine, fig. 4. Following the saws is a second pressure block, like the first one, and on each side of it are two vertical spindles carrying the side cutters for planing, tonguing, and grooving the edges of the wood. This part of the machine is shown best in Figs. 3 and 4, and it will be seen that the spindles are each driven off large pulleys at the feeding end of the machine, these pulleys being mounted on a shaft, with a third one between them, to which motion is imparted by a strap, passing the whole length of the machine to the main driving pulleys. The cutters running on these spindles are of the ordinary form for smoothing the edges, and cutting a groove on one side, and a tongue on the other. Following these are two plain revolving cutters for planing the top surface, shown in Figs. 3, 4, and 6. These are each mounted on their own spindle with a small pulley at the end, and both driven off an intermediate pulley by one strap, which then passes over another pulley on the main shaft.

Considerable credit is due to the makers of this machine for the originality and ingenuity of its design, while the workmanship is extremely good. At the same time it is large and costly, and works with a comparatively slow rate of feed. As in the case of the circular planer, though with less force, it contrasts unfavourably with the parquetry machines of Messrs. Worssam, of Chelsea, which are cheaper, more efficient, and can turn out a greater quantity of work in a given time.

Germany.

Many exhibitors of wood-working machinery were found in the German section of the Machinery Hall, and while a large number of the machines shown were copies or adaptation of English or American models there was at the same time a great amount of original, well designed, and well made, German wood-working tools. Mr. Zimmermann, of Chemnitz, one of the worst

offenders in the matter of cool plagiarism, had nevertheless sufficient original tools to save him from the charge of being a mere copyist, and at the same time the workmanship of these tools left nothing to be desired. One of the most striking of Mr. Zimmermann's exhibits was a large veneer cutting machine, with a very heavy massive frame and large table, on which is mounted a large knife bolted to a heavy cast-iron backing, which is moved along the table in guides by means of a rack and pinion. The table which supports the wood to be cut, is traversed by three slots in which are large screws and clamps for the purpose of attaching the wood.

An ingenious automatic arrangement is provided for the purpose of raising the table each time that a cut has been made, and so to bring fresh timber to the knife. A stud with a projecting finger is attached to the cast-iron backing of the veneer knife, and this in advancing trips a vertical lever, which in moving, turns a ratchet wheel by one tooth, the shaft on which this ratchet wheel is mounted carries also a spur wheel engaging in toothed gearing on a second shaft. Finally, the motion thus transferred gives a definite movement to one of four vertical screws which carry the main table of the machine, and are placed at each corner. At the bottom of each screw is a horizontal grooved wheel, around which an endless chain passes, so that the motion imparted to the first screw is thus transferred to all the others. By means of change wheels, the amount to which the table is elevated at each movement can be regulated, so that veneers of different thicknesses may be cut.

A log trying-up machine and a large moulding machine, figs. 4, 5, Plate 212, belonging to this collection may be mentioned in passing.

A speciality of Mr. Zimmermann's exhibits was a dove-tailing machine, of which illustrations will be seen in figs. 4, 5, and 6, Plate 215. In this machine four small horizontal spindles, each having its own pulley are mounted in a movable frame that can be set at any desired height or angle. At the ends of the spindles are placed tool holders, each containing four curved and radial knives. Each spindle is driven, as shown, by its own belt passing to pulleys above, carried in a balanced bracket, and the wood to be operated is fixed down on an advancing table, moved by hand through gearing as shown. The forms of the knives is such that they cut out the dovetails, each cutting one side, and the following set of knives finishing the other.

A small universal moulding machine shown by Mr. Zimmermann is illustrated in figs. 7, 8, Plate 215. It possesses no novelty, but is well made. It will be noticed that the wood may be held in position on the table by means of spring clips. Finally may be mentioned a large double circular saw, illustrated by figs. 7, 8, Plate 214, and a band saw figs. 7, 8, Plate 213. In the former of these, one of the saw blades is mounted on a fixed hollow shaft, the spindle of the second one sliding in it telescopically, a key and keyway being provided in the inner and outer shafts respectively, so that both blades are driven by one pulley as shown in the drawings. The movable saw is shifted by means of the screw and hand wheel, and the table travels with it as shown. There are two pairs of feed rollers in this machine, the feeding pair driven by gearing as indicated, whilst the pressure exerted by each pair upon the timber can be regulated by the hand levers. The band saw shown in figs. 7, 8, Plate 213, is a well made machine with tilting table, but having no speciality of detail.

The Sächsische Maschinen Fabrik, Chemnitz, showed three wood-working machines, one for cutting dovetails, and shown in fig. 1, Plate 215. This is precisely the American machine which formed a leading feature in Messrs. Robinson and Co's. exhibits, and it need not therefore be again described. The second tool, a four side moulding machine, is well made and designed It is shown on fig. 5, Plate 212. It has two pairs of large feeding rollers, the upper ones fluted and the bottom ones plain. The latter run in fixed bearings, the former are mounted at the ends of levers, and are connected by vertical rods to a table below the frame, which may be weighted at will. These rollers are driven by the usual gearing. Beyond these, and near the bottom revolving cutter, are two rollers mounted on a shaft, at one end of which is placed a lever, having an eye formed at one extremity, which passes

over the end of a vertical rod fastened to the frame. An adjustable nut presses on the end of this lever, and by its means the pressure exerted by the rollers last-mentioned can be regulated at will. The relative positions of the side cutters, which are clearly indicated in the drawings, can be modified to suit the width of the timber, being cut by means of a horizontal screw and hand wheel. The position and form of the head stock is shown in the engraving, and it will be seen that the top cutter block slides in openings in the head stock, being raised and lowered by means of screws actuated by four cross levers or horizontal shaft and bevel gear. On each side of the top cutter, is a roller kept down to its work by means of weights placed as shown. The end of the frame is continued to receive the bearings for the pulley from which the machine is driven. A boring machine by these makers is shown in fig. 2, Plate 215.

Messrs. Gschwindt and Co. of Carlsruhe, had a fair collection of wood-working machines. Fig. 6, Plate 213, shows a large band saw of a type repeated many times at the Exhibition, and met with first in the French section. It has a circular table on which are mounted two pairs of rollers for feeding through the heavy work for which the saw is designed. One pair of these rollers is smooth, the other fluted, the latter being employed for driving. As will be seen, toothed wheels are placed at the top of each roller, and they are driven by gearing in connexion with the horizontal disc shown under the table, and which is a friction wheel actuated in the manner previously described. These rollers can be fed up to the work by means of the screw and handle seen in the drawings. For light work the whole of this guiding apparatus may be removed.

Fig. 9, Plate 214, is a fair type of fret saw as represented in the German section. Although quite as good as any shown in the English section, it is not to be compared either with the American tools of this class, nor with those of M. Arbey.

A tenoning machine, a four side planer, and a mortising machine, and a universal moulding machine may be mentioned among Messrs. Gschwindt's exhibits. The two former possessed no specialities. The mortiser was a well arranged tool, but not so good as Ransome's. The chisel of this tool is formed to extract the chips, and is made with flanged sides something like Messrs. Ransome's, but their sides are serrated, so that they get an additional hold on the wood. These chisels appear to answer very well in practice. The universal moulding machine is furnished with a bracket and arm, movable in all directions, and carrying a roller for pressing upon the work. An excellent tool in Messrs. Gschwindt's exhibits was a horizontal grindstone, shown at fig. 3, Plate 215. It will be seen to consist of a vertical central standard supporting a cast iron tray, in which the grindstone revolves, being driven by gearing within the column. To the edge of the tray is fixed a vertical bracket, carrying a horizontal arm at the end of which is a suitable tool holder. In operating this machine the tool is merely placed in the holder and a slow reciprocating movement is given to it. The stone can be stopped by the hand lever shown in the drawing.

Messrs. Schmaltz of Offenbach showed a large collection of wood-working machines, including log frames, circular band and saws, moulding and trying up machines, mortising, tenoning, and universal moulding machines. While showing good work and fair design, the exhibits of these makers had no special feature to warrant a detailed description. The tenoning machine formed, however, an exception to the rest of their exhibits, being about the worst example of its kind in the exhibition. The cutting tools consisted of a series of adzes operated by cams, to imitate manual action. In the universal moulding machine a neat contrivance was seen for regulating speed, and reversing the cutter, which was driven by friction gearing, similar to that already described as forming part of several hand saws in the German department. In this case two discs were used, sliding on one shaft, so that one or other could be brought in contact with the pinion.

Did space permit, we could enlarge considerably upon the details of the different machines, we have brought under the reader's notice; we have, however, said enough to give a good idea of the present state of wood-working

machinery throughout the world, as represented at Vienna, and the prominence which we have given to the exhibits of American and English makers, is fairly due to the position which they now occupy in this industry.

SUGAR-MAKING MACHINERY AND BREWERY PLANT.

THE collection of sugar machinery at the Vienna Exhibition did not include anything like a complete plant for sugar making—it was, in fact, almost entirely confined to the evaporative part of the process. A large number of vacuum pans were exhibited, some solitary specimens of centrifugals, and a few air pumps with their engines, but (with the exception of one small roller press for macerating beetroot) we had neither on the one hand mills or apparatus for extracting juice from the cane or root, nor, on the other hand, refining apparatus for treating the sugar after it has left the pans and centrifugals. The former shortcoming was the more to be regretted, as cane mills are machines on which hitherto too little attention, scientifically, has been bestowed. We are not aware that any satisfactory experiments have been made in reference to the actual strains on the cheeks and gudgeons of cane mills when at work, and hitherto the rule has been too generally just to increase their strength, in parts known, or supposed, to be subjected to great strain, by adding more metal, until now in some cases the cheeks are little better than solid masses of cast iron. Lately, however, one or two manufacturers of reputation have been breaking loose from tradition to some extent, and have apparently been desirous of being guided in the construction of sugar machinery by the same principles which direct the engineer in designing other machinery, and a good show of mills and gearing at the Exhibition could not have failed to add impetus to this movement.

Within its own limited field, however, the show of sugar machinery was good, and contained many objects of interest, the principal of which are represented in plates 178 to 185.

The machinery exhibited may be divided into two classes, namely, machinery for making sugar from cane, and machinery for making sugar from beetroot; but there was also one very interesting exhibit of plant for extracting the saccharine matter from potatoes and other vegetables. In the first class the most important exhibit was the magnificent vacuum pan made by C. Heckmann, of Berlin, which stood near the centre of the great Machinery Hall, and formed an object of general attraction. This pan, which is shown in Plates 178 and 179, was not merely made for show, but is for a factory in Havanna, to which place it was sent when the Exhibition closed. Its design and arrangement are both excellent, as will be seen from the engravings and the following description, while its workmanship is of the very finest, especially as regards the copperwork in the shell of the pan itself.

The platform on which the pan rests is about 11 ft. from the ground. It rests on a frame of light cast-iron girders, which are in turn supported on four columns of the same metal. These columns are made square at the top, and the girders, which have brackets cast on their under sides for the purpose, are bolted to these square parts. The platform itself is made of oak, and all round it neat wooden pillars support a polished brass hand-rail. Access to it is obtained by two staircases, one on each side, the upper end of each staircase being supported by a light cast-iron pillar of similar design to the four in the centre. The platform, not including the staircases, is 6·720 metres (22 ft.) square.

The vacuum pan itself is 10 ft. 3½ in. diameter, and 11 ft. 6 in. high inside, not including the dome on the top. It differs from the form with which we in England are most familiar, by being, as will be noticed, much higher in proportion to its diameter than usual, and a tendency to increase this proportionate height was noticeable in many of the pans exhibited at Vienna. The head of the pan is made in one piece, dished out of the flat, and the body is also

made out of one sheet of copper, so that the pan above the flanges consists, excluding the dome, of two sheets of copper only. The flanges are made of wrought iron $\frac{5}{8}$ in. thick, the copper coming, of course, inside the iron. The total height of the upper part of the pan from the flanges to the bottom of the dome is 6 ft. 11 in., and the brass dome on the top of it is 3 ft. $9\frac{1}{2}$ in. diameter, with a hemispherical top united to it by brass "angle irons," if we may use the expression. The bottom of the spherical part of the pan is 3 ft. $0\frac{1}{2}$ in. above the platform, and for this height the pan is covered in with wood. The pan itself is here nearly cylindrical, but somewhat larger at the top than at the bottom, to allow of the steam rising freely. Below this cylindrical part and also below the level of the platform itself, comes the bottom of the pan, which is double, as usual, both the inner and outer bottoms being of copper. The inner bottom is approximately part of a sphere of about 5 ft. 4 in. radius, and the space between the two is—in the centre—nearly 4 in. Each of these bottoms is made from one piece of copper, so that the whole pan has actually been made from five sheets only—the top, the body, the lower body, and the two bottoms. The discharge pipe (brass) which is $15\frac{3}{4}$ in. diameter, is put in from the inside with a flange, and the inner bottom is dished so as to allow the top of the flange to be flush with the surface of the copper, and present no impediment to the flow of the sugar. A brass ring fills up the space between the dishing and the outer bottom, and another brass ring, outside the latter, also encircles the discharge pipe and makes its external diameter equal to that of the flange of the cast-iron nozzle immediately below it.

The pan is supported by short cast-iron brackets, so that the lower flange of the lower or cylindrical body is a few inches above the top of the platform girders. The height of the whole from the ground to the top of the dome is 8·300 metres, or 27 ft. 3 in.

The pan contains 646 square feet of heating surface, counting the tubes only, and not including the bottom, which contains 58 square feet more. There is in all a length of about 484 ft. of copper tubes, of $5\frac{1}{16}$ in. diameter externally. The tubes are arranged in five sets, the two highest sets communicating with each other, and having only one valve outside, and the other three having each their own separate steam valve. The exhaust from all the tubes—perhaps it would be more correct to say drainage than exhaust—is into the double bottom, and from this the water is led away, passing through a steam trap to the tank from which the boiler draws its feed water. Each set of tubes contains five rings, so that there are in all 20 circles of tubes. The lowest set lies at a considerable angle upwards towards the circumference of the pan, and the rest are so arranged as to offer a minimum resistance to the free escape of the steam through the boiling sugar, a point, even when boiling *in vacuo*, of importance. The tubes are supported and connected by brass brackets, and are so placed in the pan that the upper set are just level with the valves through which the sugar is admitted.

The fittings with which the pan is furnished are as follows:—two testers (with tray), passing between the two topmost sets of tubes, one tester being short, and the other reaching nearly to the centre of the pan; four spy-glasses ranged one above the other, and a lamp with reflector on the opposite side of the pan; four ordinary conical hand valves, $4\frac{3}{4}$ in. diameter, for admitting steam of low pressure to the heating tubes, and on a branch from the inlet pipe of each of these a smaller valve, $1\frac{3}{4}$ in. diameter, by which steam direct from the boilers can also be admitted when necessary; two valves, each 3·15 in. diameter, for admitting the sugar; thermometer, vacuum gauge, steam gauges for both low pressure and direct steam, butter cock, valve for flushing the interior with water, valve for admitting steam direct into the pan from the boilers, &c. All these valves and fittings are neatly made in brass, and polished, but they do not call for any special mention.

The arrangement for working the discharge valve from the platform is very neat, and is shown clearly in the engravings. The valve is simply a disc of brass working on the cast-iron face of the discharge nozzle, the atmospheric pressure being sufficient to keep it tight. A bracket from the nozzle carries a pin on which works a double-ended lever in a horizontal plane. One

arm of the lever is rigidly connected with the under side of the valve, and the outer end of the same arm is guided between horizontal bars. The end of the other arm is connected by short links with a brass nut on a long screw, and motion is given to this screw through bevil gearing, by a handwheel on a cast-iron pillar on the platform above. The whole arrangement is both neat and substantial. One charge of this pan amounts to 20,000 kilogrammes—or nearly 20 tons—of sugar, and under favourable circumstances three charges a day may be worked, although this cannot be expected to be the average yield with native labour in Havanna.

The firm of C. Heckmann also exhibited some specimens of their copper and brass working. The most remarkable of these were two fireboxes for locomotives and one large sheet of copper. One of the fireboxes (of $\frac{1}{2}$ in. copper plate) has its crown and sides (which are all made out of one plate worked by hammering into corrugations 1 in. deep, and about 5 in. broad, for the sake of giving increased rigidity, in accordance with Mr. Haswell's system. The single sheet of copper just mentioned is of the extraordinary dimensions of 7 ft. 2 in. wide by 41 ft. 2 in. long, and $\frac{1}{4}$ in. thick. The rolling of it, from the time it entered the rolls until it left them in its present shape is said to have taken only 10 minutes.

The Maschinenbau Actien Gesellschaft (formerly Danek and Co.), of Prague, exhibited a beetroot diffusion battery, consisting of 10 vessels, with all their fittings and pipes complete, and which are shown in Plate 180. The principal peculiarity of the battery is, that it is fitted with Bromovsky and Urbanek's patent self-emptying apparatus, which is intended to obviate the great loss of time commonly incurred in emptying the vessels of their contents. Its application seems to have been very successful, the operation, which took 10 minutes before, being now effected by it almost instantaneously.

The battery consists of 10 wrought-iron vertical cylindrical vessels, with conical bottoms, each 4 ft. 5 in. in diameter, and 9 ft. 4 in. long (English measurement), and having a capacity of about 130 English cubic feet. They are supported on brackets on horizontal girders at a proper height from the floor. They have each, both at top and bottom, a manhole, and these can be thrown open or closed simultaneously by simple arrangements of levers. Diffusion vessels were formerly made cylindrical right down to the bottom, but it was found with that construction very difficult to empty the lower corners of the cylinder, in which the beetroot lodged, and in consequence of this the lower parts of these vessels are now made conical, as shown in our engravings. The whole of the cone has an inner perforated bottom, to prevent anything but juice passing into and choking up the pipes, these communicating only with the space underneath this inner bottom. A very complete arrangement of pipes is fitted for conveying the juice from one pan to another, to and from the heaters, &c. The contents of the vessels, when they are emptied, fall into a large trough, either of brick or iron (not exhibited at Vienna, but shown in the engraving), lying underneath them, which has a slope of about 3 ft. in the length of the battery. By this the beetroot from which the juice has been extracted is carried to an accumulator near the refuse presses, or wherever else it may be desired to conduct it.

The principles of the diffusion process is well known, but may be briefly recapitulated here. We may commence with the moment when one of the vessels, having just been emptied, has been refilled with fresh beetroot cuttings. The whole of the ten vessels are now standing filled with beetroot containing a certain proportion of extractible juice. If the vessels are numbered from 1 to 10, and the total amount of juice which can be extracted by the process be represented by 100, then No. 1 vessel contains beetroot from which 90 per cent. of this has been extracted, and from which therefore 10 per cent. can still be taken; No. 2 contains beetroot from which 20 per cent. can be taken; No. 3 beetroot from which 30 per cent. can be taken, and so on till we come to No. 10, which contains the fresh cuttings. Each vessel also contains liquid having a capacity for absorption of more saccharine matter in something like inverse ratio to the amount of extractible matter in the beetroot. Thus No. 1 vessel contains fresh water, warmed to the proper temperature, but destitute of juice, No. 2 contains water with 10 per cent. of

juice, No. 3 with 20 per cent., and so on to No. 10, which contains water with 90 per cent.. as much juice as it can obtain before it goes to the next process. In about 15 minutes the fresh water in No. 1 will have absorbed the 10 per cent. of juice left in the contents of that vessel, which may therefore now be considered worthless as far as this process is concerned. The thin liquid in No. 2 will have taken up 10 per cent. of the 20 per cent. of juice remaining in that vessel, so having itself 20 per cent., and leaving 10 per cent. in the vessel. In the same way the root in No. 3 will be left with 20 per cent. of extractible juice, and so on, till in No. 10 the fresh cuttings will have lost 10 per cent. of their juice. Vessels Nos. 1 to 7 are now all put in communication with each other, No. 7 is connected with one of the warming pans, and No. 1 with the water reservoir. The latter stands at a height of 35 ft. to 40 ft., and the warmers from 9 ft. to 12 ft. above the top of the battery, and the difference between these heights gives an available head of 25 ft. or 30 ft., which is quite sufficient to drive the liquid contents of each pan into the next one (that is, No. 1 into No. 2, No. 2 into No. 3, &c.), and the juice in No. 7 up into the warmers. As soon as this has taken place, and there is nothing in No. 1 but the beetroot from which the whole available juice has been extracted and the fresh water, it is shut off from the rest of the battery, emptied, and refilled with fresh cuttings; it is now, therefore, in the position in reference to the rest of the battery in which No. 10 vessel was at the commencement of the process. At the same time that the last process was going on, while vessels Nos. 1 to 7 were all in communication, a separate communication was opened between one of the warmers (*not* the one into which vessel No. 7 has been emptying itself), and No. 8, and also vessels 8 to 10 were connected, and the latter was opened to the discharge pipe. The head of the liquid in the warmers was sufficient to fill up vessel No. 8 with freshly heated juice, and to transfer its last contents to No. 9, those of No. 9 to No. 10, and to force those of No. 10 through the discharge pipe to the saturators. Communication is now set up through the whole battery No. 2 being connected with the reservoir, and No. 10 with No. 1, which, it will be remembered, has just been filled with fresh beetroot, and contains no liquid. The contents of each vessel are forced into the next one (2 into 3, 3 into 4, ...10 into 1), and in every detail the battery stands exactly as it did at the point where we commenced our description, except that No. 2 is in the position of No. 1, No. 3 of No. 2...No. 1 of No. 10. The whole process goes on again, and at the end of it the contents of No. 2, having no more extractible juice, are emptied as No. 1 was before. Fresh cuttings are introduced, and the same operation repeated, No. 3 this time becoming No. 1, and so on in endless rotation. Each vessel in this way has juice passed through it 10 times before it is emptied. As each complete operation, or shifting of the juice, takes about 20 minutes, there are 60 to 80 emptyings a day, and when it is remembered that the whole process stands still during each emptying, the value of Bromovski and Urbanek's apparatus becomes evident. The method of emptying a pan is as follows: The vessel to be emptied is shut off from all connexion with the rest of the battery. The cock *i* is then opened, and a small quantity of water issues from it, till an equilibrium between the atmosphere and the column of water in the vessel is obtained, this taking place in a few seconds. The screw U is then loosened, the upper and lower manhole opened simultaneously, and the whole contents of the vessel are instantaneously emptied into the trough below. Any small pieces of beetroot adhering to the side of the vessel are washed off with a jet of water from the cock G, and the vessel is at once put in order again, and refilled with beetroot.

The following references to the engravings may help to make the descriptions clearer. A is the pipe from the water reservoir, B is the pipe from the heaters to the battery, and D the pipe from the battery to the heaters; E is the discharge pipe for carrying the juice, when it has passed through the battery, to the next process, the saturating pans; F is the pipe by which the juice from each vessel is conveyed upwards on its way to the next vessel, the heaters, or wherever else it may be going; G is a cock with an india-rubber tube and brass nozzle, for cleaning the vessel, as already mentioned; H is a

lever for opening the lower valve on the manhole, and U is a screw for tightening it up when closed; *i* is an equilibrium cock, the use of which has been already explained; K is the conical bottom of the vessel, and M a cast-iron manhole rivetted on to K; O is the upper manhole, and P P the brackets supporting the vessels on the girders T T. The perforated inner bottom of the vessel is marked S and S^1.

Bromovsky and Urbanek's apparatus was first applied in 1872 in a sugar works in Bohemia, and the apparatus at the Exhibition embodied several improvements suggested by experience of its actual working. In the course of last year we understand that nearly a dozen factories have been fitted with it. The warming pans, or reheaters, were not exhibited at Vienna. The older pans are now being to some extent superseded by a much simpler arrangement, by which the juice enters at one end and leaves at the other a vessel arranged exactly like a surface condenser. The steam for heating the juice is outside the tubes, while the juice passes through them. The use of this necessitates some trifling modifications in the process as we have described it, but all the important points remain the same.

The roller press of Messrs. C. Wollmann and Co. (manufactured by Mr. J. Aders, of Neustadt-Magdeburg), which was exhibited at Vienna, and which is illustrated by Figs. 4, 5, 6, Plate 181, is intended to be used instead of the direct hydraulic press commonly employed in extracting the juice from beetroot. The advantages claimed for it are that it is simple in its construction and mode of use, requires no superintendence beyond the feeding, and saves entirely the expense of the press cloths, which latter form a not inconsiderable item in the cost of extracting the juice by the older process.

The machine consists essentially, like a cane mill, of three horizontal rollers supported at the ends by cast-iron cheeks, but the mode of its action is entirely different from that of a cane mill. The beetroot is first fed by hand into a hopper lying parallel with the rollers. In the lower part of this hopper the beet is brought into contact with one side of the bottom roller. This roller is of cast iron, 260 mm. (10·246 in.) in diameter, and 800 mm. (31·496 in.) long, and instead of being circular it is fluted, as will be seen from the engraving, with six large grooves. Between the grooves a small portion of the roller is left the full diameter, and turned up true. As the roller revolves the bottom of it moves in the direction away from the hopper, and carries with it portions of beetroot, filling each groove or flute in succession. To illustrate the working of the machine we will describe the treatment undergone by one of these portions of the beetroot. On leaving the hopper, it is confined, but without being compressed, for nearly half a revolution between the roller on the one side and the wall of a cylindrical chamber (which the circumference of the roller just touches) on the other, and it is in this way carried upwards with the rotation of the roller. The cylindrical chamber shortly terminates, and when by its continued motion the groove under consideration is brought to the top of the roller, the beetroot receives its first pressure between the terminating edge of the chamber, and a plate which—pivoted on an axis running parallel to the rollers—is made to bear constantly on the surface of the roller, and prevent any beetroot being carried over the centre and back again into the feeding hopper.

The beet, having undergone this preliminary pressure, is now confined in a chamber of which the bottom is formed by the plate above mentioned and the lower roller, continually bringing up its fresh supplies of material; while the sides are constituted by the sides of two cast-iron troughs which lie immediately under the centres of the upper rollers (and almost touch them), and the top by the peripheries of these rollers themselves. The two upper rollers are made of cast steel; they are 210 mm. (8·267 in.) in diameter, and of the same length as the lower roller. Their surface is covered with very fine grooves, less than a thirty-second of an inch in width, and about an eighth of an inch apart, and they are set as close to each other as possible—with their surfaces touching, in fact. The inner sides of these rollers revolve upwards, and so draw the beetroot up between them, this being the only mode of egress it has from the chamber in which it is confined. It thus undergoes the most severe pressure possible, as practically it must pass through the very

small grooves just mentioned. The juice pressed from it runs back down the surface of the rollers through the small space allowed between them and the sides of the troughs above mentioned, and eventually drops off the bottom of the rollers into these troughs, from which it is conducted away by pipes from the side of the press. The compressed beetroot itself, carried up between the rollers, is prevented by a steel plate from passing over the one on the side next the feed hopper, and is therefore compelled to pass over the other into the discharge hopper, from which a self-acting apparatus (not exhibited) carries it away, mixes it with water, and conveys it to the feed hopper of a second press, where it undergoes another and final pressure. The roller grooves are cleaned, as they pass downwards, by a row of small steel blades, which act as scrapers, one to each groove.

The gudgeon of the lower roller is cast in one piece with it, and those of the upper rollers are of cast steel, also in one piece with the rollers themselves. The cheeks of the mill are of cast iron. The driving gear and apparatus for regulating the contact of the upper roller is all of a simple and substantial construction, but does not require detailed description.

This size of mill works up about 35 cwt. of beetroot per hour. The proportion of juice obtained by it to the beetroot is, on an average, 60 to 70 per cent., the yield of course varying the amount of water which may be required to be used, as well as with the quality of the beetroot and other circumstances. The speed of the roller is about six revolutions per minute.

The firm of J. Aders, of Neustadt-Magdeburg, have, since 1850, been well known as manufacturers of machinery for the evaporation of beetroot sugar. In 1853 they acquired the right of manufacture under Sischbein's patent, and within the next five years manufactured 200 sets of the so-called "Robert's" apparatus, the first apparatus that was largely used for concentrating beetroot juice under a pressure less than that of the atmosphere. Since that time they have made frequent and important improvements in the construction and design of this machinery, and have succeeded in rectifying the principal defects which were found to exist in connexion with the original apparatus. They exhibited at Vienna the evaporating boilers, which are shown in Figs. 1, 2, 3, Plate 182, and which contain all their latest improvements, and are, we believe, the largest of their kind ever made.

This evaporating apparatus consists of two similar multitubular boilers placed horizontally side by side, with a space of about 3 ft. between them. Each boiler is 8 ft. 3 in. diameter, and 10 ft. 8 in. long (in English measure), and contains 510 tubes, $2\frac{1}{16}$ in. diameter, and made of brass, weighing 3 lbs. per square foot. The total heating surface in the two boilers is thus about 5,800 square feet. The method of packing the tubes (which previously gave much trouble by leakage), is a novelty, and merits description. It must be remembered that the steam is only of some 6 or 7 lbs. pressure above the atmosphere; of course the method would be useless for high pressures. The end plates of the boiler are the tube plates, and are drilled for the tubes in the usual way. The tubes are not attached to the plate at either end, but are left perfectly free to expand. The packing apparatus is the same at both ends, and is made as follows: round each tube is slipped a ring of india-rubber, which is pressed close up to the tube plate. Outside this ring a thick wrought-iron washer is placed, fitting pretty closely the outside of the tube, but projecting considerably beyond the end of it. Between each set of three tubes a wrought-iron stud is tapped into the tube plate. Over this is slipped a three-clawed guard, the body or cylindrical part of which rests on the sides nearest it of the three surrounding washers, and the extremities of the claws rest on the outer edges of the washers. By tightening up a nut placed on the stud above the guard, the whole three india-rubber rings can thus be simultaneously compressed each in two places. A glance at the engraving, Fig. 3, Plate 182, will make this method of packing clear.

The topmost row of tubes is just level with the centre of the boilers. They communicate at each end with a closed chamber, of which the cover is secured and kept tight by bolts and nuts. To the hinder pair of chambers the steam is admitted through valves 10 in. diameter, but it is condensed

before it reaches the front chambers, and only small water pipes require to be provided to carry it away.

Between the boilers stand the two "safety vessels" as they are called, the use of which is to retain any juice which may be carried over by the steam, and prevent both waste of sugar and the choking up of the tubes or air-pump valves. These vessels are cylindrical, 18 in. diameter, and about 12 ft. high. Each contains a second cylinder, or rather pipe, 10 in. diameter, extending some way down into it, open at the bottom but passing steam-tight through the top. The steam and whatever sugar may have become mechanically mixed with it, is admitted into the annular space between these two cylinders close to the top of the safety vessel. A diaphragm, arranged spirally, winds down this space, the steam is compelled to follow its course, and in doing so deposits on it the greater part of the sugar juice. If any juice is still left in the steam when it arrives at the bottom of the spiral and the open end of the inner cylinder, it drops here into the receiver below, while the steam ascends through the inner cylinder, either to do more work or to find its way to the condenser, as the case may be. The lower part of each safety vessel forms a receiver for the juice which has been carried over. A large glass gauge shows the height at which the juice stands in it, and a valve is provided at the bottom to empty it when sufficiently full.

The mode of action of the apparatus is as follows: the low-pressure steam (the exhaust from the steam-engine, about 3 or 4 lbs. pressure per square inch) is admitted through a 10-inch valve into the back tube chamber of the first boiler. With this steam is generally mixed a small quantity of steam direct from the steam boilers through a separate and smaller valve, as shown in our engravings. Imparting its heat to the sugar juice the steam is, as we have said, itself condensed by the time it reaches the front tube chamber. The steam from the boiling juice is carried from the top of the dome up through a copper pipe (tapering from 12 in. to 10 in. diameter) to the first safety vessel, of which the construction has just been described. Here it is cleansed of juice—the juice being preserved for reboiling—and ascending through the inner cylinder it is conducted by a 10-in. copper pipe to the back tube chamber of the second boiler. Its heat (occasionally increased by adding a little steam direct from the boiler) is sufficient to boil the juice in this boiler, and in doing this work it itself is condensed and drawn off as water. The steam given off by the juice in the second boiler is conducted to the second safety vessel, and having been there freed from its sugar, passes to the condenser, and then, in the form of water, through the air pumps in the usual way.

The domes of the boilers are so arranged that the steam cannot pass directly through them, but is compelled by diaphragms, after having nearly reached the top, to return, and then ascend again, and in this way it is freed from a considerable part of the juice it may have carried up with it.

The boiler which is first used is called the thin-juice pan, and into it the juice is first introduced when it comes from the filters. It is here boiled under a pressure some 4 or 5 lbs. below that of the atmosphere, this partial vacuum being obtained by the condensation of its steam in the tubes of the second boiler. The juice is then taken from the first boiler to the second, which is called the thick-juice pan, and here undergoes its final concentration *in vacuo*, or at least in as complete a vacuum as can be obtained by the condenser.

The tubes are all made of brass, and without seam. They have the advantage over iron tubes (besides being better conductors of heat) that they keep clean and free from incrustation. It has not been found that, at least in these horizontal boilers, there is any injurious galvanic action between the brass tubes and the iron plates.

These boilers and safety vessels of Herr Aders are provided with an entire duplicate set of valves and pipes, so that by merely inserting blank flanges in the necessary places, either can be used separately—either can have its evaporation conducted by the steam from the other—or if required, the contents of both can be boiled with fresh steam, and both put in communication with the condenser and air-pump.

The fittings of the apparatus are very much the same as those of an ordinary cane sugar vacuum pan; including sugar inlet valves 2½ in. diameter, outlet and communication valves 2½ in. diameter, glass gauge, testing gauge, thermometer, vacuum gauge, peepers and lamp, cleaning cock, cock for admitting direct steam to interior of boiler, manhole door, &c.

About 5,000 centners (250 tons) of juice can be boiled by this apparatus in a day of 20 working hours, the allowance of heating surface being over one square foot of heating surface per cwt. per day. The juice enters the apparatus at a density of about 6 degrees Baumé, and leaves it concentrated to 24 degrees Baumé. Under average conditions about four charges are worked in a day.

Close to this beetroot apparatus, Herr Aders exhibited a very neat and complete working model of a copper vacuum pan for cane sugar, shown in Fig. 3, Plate 181. The model is beautifully made, and was worth examining. It is furnished with a complete set of fittings, including even the testers, thermometers, and gauges, all executed on a very small scale. About the design of the pan itself we need not say anything, but the neat arrangement of combined condenser and tell-tale may be described. As will be seen from the dotted lines, the steam from the pan is not allowed to pass directly upwards and into the tell-tale, but is made to fall and then rise again by a kind of cap, which is placed in the dome above the mouth of the pipe coming up from the pan. In this way, probably, the heavier part of the juice may be separated. After passing out of the dome the steam makes its way through the connecting pipe into the tell-tale, which is really an annular space fitted with a spiral diaphragm very similar to that in the safety vessels above described, and answering the same purpose. Rising, in contact with this diaphragm, into a space of ever decreasing size (as the inner chamber or condenser tapers outwards), it parts with all its sugar, which finds its way to the receiver at the bottom of the column, and is then itself condensed in its passage downwards through the inner vessel by jets of water from perforations in the small copper pipe. The valve on the right-hand side of the receiver is in communication with the suction pipe of the air pump.

Herr F. Hallström, of Nienburg-on-the-Saale, exhibited a very complete and interesting set of evaporating apparatus for beetroot sugar making, on the double-pan system, and which is shown in Plate 183. This apparatus is not so large as that of Herr Aders, of Magdeburg, but is in every way as complete, and is arranged in an entirely different manner. We notice that it is expressly stated by Herr Hallström that his exhibits (which included also a copper vacuum pan), were not constructed specially with a view to show at the Exhibition, but were intended to be fair samples of the usual productions of his factory.

Before proceeding to a detailed description of the construction and working of these boilers, it will be well just in a few words to describe their general arrangement. The beetroot juice is introduced first into the boiler on the left-hand side of the engraving—the "thin-juice pan." Here it undergoes its first concentration by being heated with low pressure steam drawn from the engines and a certain amount of direct steam from the boilers. The vapour from the boiling juice passes up through the dome and through the rear safety vessel into a steam chamber at the back of the second boiler or "thick-juice pan." This boiler receives the partially concentrated juice from the first, and the concentration is here completed by the heat from the steam of the first boiler, which is compelled to pass through the tubes. The steam from the boiling juice in this second boiler is passed through a safety vessel and then condensed in the usual way.

The thin-juice pan is a plain cylindrical wrought-iron boiler 1·75 metres (5 ft. 9 in.) diameter, and 3·180 metres (10 ft. 5 in.) long. A rectangular steam chamber or box, also of wrought-iron, and about 12 in. deep, crosses its front, and the steam is admitted to this box by either one of two valves placed at its ends. From this chamber there lead into the boiler 15 copper pipes, which are so arranged that each one (except the two side ones, which are somewhat shorter), traverses the whole length of the boiler six times, and then is again connected with the front tube plate—but at a much lower level than the

steam chamber—and has a small valve attached to it to let off the water. The valves, however, are not allowed to communicate directly with the atmosphere, but are so connected with a long wrought-iron cylinder in front of the boiler that no uncondensed steam is permitted to pass away along with the water. The steam that is used in these tubes is the exhaust steam from the engines about the factory, and will consequently possess a pressure of about 3 or 4 lb. per square inch above the pressure of the atmosphere. In the lower part of the boiler, below these tubes, are two sets of smaller pipes (each arranged to traverse the length of the boiler six times) which are supplied with steam direct from the steam boilers through separate valves, placed near the back of the pan.

The second boiler, or thick-juice pan, is entirely different in its construction from the first. It is also 5 ft. 9 in. diameter, but is only 2·89 metres (9 ft. 6 in.) in length. It has a tube plate at each end, and contains 140 brass tubes 56 mm. diameter (2·20 in.) running from end to end and communicating at each end with a separate chamber. The chamber at the rear end receives the steam from the boiling juice in the thin-juice pan, but a valve is provided by which low pressure steam can be introduced to it directly (as to the thin-juice pan), if it should be desirable or necessary to do so. The chamber at the front end of the boiler is much smaller than the other, and is provided only with cocks for drawing off the condensed water. The tubes are kept tight by means very similar to those often used in surface condensers, viz., as follows: each end of the boiler (up to the level of the top tubes) consists of two thicknesses of plate, rivetted together, making up a total thickness of 40mm. (1·57 in.). The holes in the inner plate are made as nearly as possible the same diameter as the tubes, which passing through them are left perfectly free to expand. The outside plate has holes concentric with the others, but considerably larger in diameter, so as to form a kind of stuffing box round each tube. Into this an india-rubber ring is slipped, then a thin brass washer, and then the whole is made tight by a brass gland, screwed into the outer tube plate. This system of packing is expensive, but it ought to be thoroughly effective.

The domes of both boilers are alike, and are each fitted with internal chambers, as shown in dotted lines, for intercepting the sugar carried up by the steam. The top of each is connected by a copper pipe with the middle safety vessel, but under ordinary circumstances only the second boiler actually communicates with this vessel, the communication with the first boiler being closed by a blank flange. The construction of the safety vessel is clearly shown in the drawing. The steam from the boiler obtains access near the upper part of the vessel to the annular space left between its inner and outer cylinders. It is then compelled to pass down a spiral passage by an intercepting diaphragm, and the sugar which has been carried over by it, intercepted by this diaphragm, falls to the bottom of the vessel, while the steam ascends through the inner cylinder or pipe, and is led away by it to the condenser. A glass gauge on the lower part of the vessel shows the level of the sugar juice in it, and a small valve is fixed to its bottom with pipes to convey the juice back to either of the two boilers. In the usual mode of working this apparatus, as before explained, the steam from the juice in the first boiler, prevented from communicating with the middle safety vessel, passes through a pipe to a somewhat similar vessel placed on the top of the steam chamber at the back of the second boiler. Having been by this vessel freed from sugar, it passes through the tubes of the second boiler, and is itself condensed by imparting its heat to the contents of that boiler.

The total heating surface of the copper tubes in the first boiler amounts to 52 square metres, or 559 square feet, and the total heating surface of the brass tubes in the second boiler amounts to 70 square metres, or 753 square feet. The boilers are mounted with a complete set of fittings, which are clearly shown in the engravings. They include the following: main steam valves, 6 in. diameter; juice induction valves 65 mm. (2·55 in.) diameter; juice eduction valves, 75 mm. (2·95 in.) diameter; a complete set of water escape cocks for tubes of first boiler, with valves for preventing loss of steam, admission and egress valves for direct steam to the lower pipes in the first

boiler, vacuum gauges, thermometers, butter cocks, glass gauges, testers, peepers, &c. The larger fittings are of cast iron with brass valves, the smaller ones entirely of brass, the domes and safety vessels, as well as the boilers, are of wrought iron, and the steam pipes of copper.

Figs. 1, 2, Plate 181, show a vacuum pan for crystallising sugar (either from beetroot juice or cane juice) manufactured by the same maker. This pan differs in construction in many respects from the ordinary design, and is in principle analogous to the evaporating apparatus above mentioned. In most sugar evaporating apparatus the steam employed to boil—or "cook," as the Germans say—the sugar, is a mixture of "return steam," which is simply the exhaust steam of the factory engines, with steam direct from the boilers. The quantity of each admitted to the heating pipes is regulated exactly by means of valves, but the two kinds of steam are admitted together, and mixed in the pipes. In Herr Hallström's beetroot evaporating boilers—or rather in the first of them, the thin juice pan—both direct and return steam are used, but instead of being mixed they are admitted into entirely separate ranges of pipes. The same system is adopted in this vacuum pan. It contains two sets of pipes, (each having five complete rings,) and the upper set, which is considerably smaller than the other, receives only direct steam, while the lower set receives return steam or mixed steam in the manner which we shall presently describe.

The vacuum pan is made of copper, and is very nearly spherical in form. It is supported from the floor of the building on four neat cast-iron columns. Its principal dimensions are as follows :

	feet.
Diameter - - - - -	6·8¾
Height inside - - - -	6·8¾
Diameter of dome - - - -	2·1½
Height of dome - - - -	4·11
Greatest space in double bottoms - -	·4⅜
Height inside to face of flanges - -	1·9⅝
Total height of apparatus from floor to face of top flange - - - -	13·1½

From the top of the vacuum pan a pipe leads up nearly to the top of the dome, but the steam is prevented from finding any direct exit by a cylindrical chamber, with closed top, being placed in the dome so as to cover the top mouth of this pipe. The steam is thus forced to descend outside the pipe, and ascend again through the annular space left between the cylinder and the dome before it can finally reach the pipe leading to the condenser.

The arrangement of the tubes inside the pan is clearly shown by the drawing. The arrangement of the valves, though somewhat complicated, is very complete and ingenious, and merits special description. The valves are arranged so as to secure that the steam may be admitted and circulated in the following different ways : 1. Direct steam can be admitted to the upper tubes, the lower tubes, or the double bottom. 2. The steam from the upper tubes can be passed either to the lower tubes, the double bottom, or the steam collector. 3. The steam from the lower tubes can be admitted either to the double bottom, or to the steam collector. This is a separate vessel (not exhibited at Vienna, and not shown in the drawings) into which the different steam engines in the factory exhaust, and in which the exhaust steam is reduced to a common pressure; it is therefore practically the same as an expansion box. Eight valves suffice to regulate the distribution of the steam and communication described above, and the way in which they do so will be easily understood by the following reference to the engravings.

a. 2½ in. valves for admitting steam direct to the upper tubes.
b. 2 in. valves for admitting steam direct into the lower tubes.
c. 2 in. valve for passing steam from upper to lower tubes.
d. 1½ in. valve for passing steam from the upper tube to the steam collector.
e. 1¼ in. valve for passing steam from the upper tube to the double bottom.
f. 1¼ in. valve for passing steam from the lower tubes, to the steam collector.

g. $1\frac{1}{4}$ in. valve for passing steam from the lower tubes to the double bottom.

h. $1\frac{1}{2}$ in. valve for admitting direct steam to the double bottom.

The discharge valve which shuts with an india-rubber joint is $10\frac{5}{8}$ in. diameter, and is worked through a long lever by means of a hand-wheel and worm. In the engraving *k* is a $1\frac{1}{4}$ in. additional valve, on the double bottom, in connexion with the pipe conveying the steam from the upper and lower tubes: *l* is a $1\frac{1}{4}$ in. valve for admitting water to cleam out the pan, *m* is a $1\frac{1}{4}$ in. valve for admitting steam to the interior of the pan: *n* are the valves for admitting the sugar juice to the pan: and *o* is the main discharge valve. The pan possesses all the usual fittings quite complete, including manhole door, tester, butter cock, vacuum gauge, thermometer, peeper with lamp, &c., all the mountings being of brass.

The total heating surface including the double bottom amounts to 25·6 square metre, or 275·4 square feet. It works in one charge from 6,500 to 7,000 kilogrammes of sugar, or $6\frac{1}{2}$ to 7 tons.

Salomon Huber, of Prague, exhibited in the Eastern Agricultural Machinery Hall a quantity of machinery. There was a large vacuum pan of copper about 7 ft. diameter, complete with all its fittings, and erected on a platform. There was also a defecator with cast-iron hemispherical bottom, and copper cylindrical top—the usual construction; a safety vessel and apparatus for preventing waste of sugar; a vertical beetroot vacuum boiler; and a very complete plant, with washers, macerators, engines, and air pumps, concentrators, condensers, &c., for extracting sugar from potatoes and other vegetables.

Messrs. Gallauner and Stabenau, of Prague, exhibited a copper vacuum pan with cylindrical middle body. It was not mounted on its platform, but merely supported on short cast-iron brackets. Its workmanship is very good, but it presents no special features in design to call for comment. A concentrating box was also shown, and a number of copper pipes and bends, and copper and brass valve boxes, all shewing very excellent workmanship. The same firm exhibited a large vertical beetroot vacuum boiler or pan, cased in wood. It is made of wrought iron entirely, as are most beetroot boilers; but what struck the eye of the visitor was that all the valve boxes, &c., usually of brass, are also made of wrought iron, and polished. Any intelligible reason for this we have not been able to discover, and are compelled to come to the conclusion that it is an entirely useless waste of labour and money.

Johann Troetzer, of Warsaw, exhibited a small copper vacuum pan on cast-iron brackets, with copper condenser attached, not calling for any remarks.

Messrs. Demorsier and Mengotti, of Bologna, exhibited a cast-iron vacuum pan, with cast-iron tell-tale, &c., and a complete set of fittings. They also showed a neat air-pump engine. The cylinder and pump are attached to one bedplate, and the piston prolonged does duty also as the air-pump rod. A crosshead is attached to the rod midway between the cylinder and the pump, and two connecting rods, one from each end of the crosshead, give motion to a shaft running across behind the cylinder, and carrying two light flywheels. The design of the engine is good, as is also that of the pan, &c., but the workmanship throughout is not what we are accustomed to consider first-rate.

The French Compagnie de Fives-Lille exhibited a complete set of evaporating apparatus, the vacuum pan is cylindrical, and of wrought iron, and set on a platform with cast-iron framing and columns.

Messrs. Lilpop, Rau, and Co. (Warsaw), exhibited one boiler, somewhat similar to those above, a centrifugal machine, and also a double cylinder air-pump engine and other machinery. These machines, although small in size, showed careful and finished workmanship in their various parts.

Figs. 4, 5, 6, 7, 8 show the construction of filter presses by Mr. A. L. G. Dehne, Halle-on-the-Saale. These presses are referred to in the section on Miscellaneous Exhibits.

BREWING PLANT.

THE brewery plant at the Vienna Exhibition formed an important and interesting series of exhibits, and one which well repaid examination. The Continental brewing processes differ, as is well known, very materially from our own, in many of their most important details; but the mechanical arrangements employed are nevertheless many of them equally applicable for use here, and we believe that many of our brewers would have gained some useful hints by having investigated the brewing plant shown at Vienna. Figs. 1, 2, 3, 4, Plate 184, show an excellently got up set of brewing plant exhibited by the Chemitzer Maschinenbau Gesellschaft (formerly A. Münnich and Co.), of Chemnitz, a firm well and favourably known on the continent as makers of machinery and apparatus for breweries.

This set of brewing plant is adapted for mashing 3,000 kilogrammes (6,600 lb., or nearly 20 quarters) of malt, 100 hectolitres (2,200 gallons, or about 61 barrels) of wort being obtained at each mash. The whole arrangement, is based upon the "thick mash" system of brewing generally adopted in Germany, and in describing the apparatus it will be advisable at the same time to give an outline of this system of brewing, so that the uses of the various parts of the plant may be more readily followed.

Referring to the engraving, it will be seen that the principal parts of the plant consist of an iron mash tun, A; an iron clarifying tun, B; an iron mash boiler with copper bottom, C; and an iron boiler or brewing pan, D, these utensils, with their pipes, &c., being mounted and connected by platforms and staircases, as shown. The dimensions of the various vessels are marked on the engraving, and the capacities are as follows: mash tun, A, 188 hectolitres = 4,136 gallons; clarifying tun, B, 182 hectolitres = 4,004 gallons; mash boiler, C, 96 hectolitres = 2,112 gallons; and wort boiler or brewing pan, D, 179 hectolitres = 3,938 gallons. The mash tun A and clarifying tun B are cleaded with wood to prevent the loss of heat by radiation, and the two boiling vessels C and D are set in brickwork and directly heated by fires beneath them, as shown in Figs. 2, 3, and 4.

In commencing brewing operations the mash boiler C is filled with water which is heated to the desired temperature. The crushed malt is then fed into the mash-tun A through the preliminary mashing machine H, this latter consisting of a cylinder, into which the malt is fed from a hopper, the neck of the cylinder being provided with a circular rose, through which water is discharged. The mash is thus delivered into the mash tun in the form of a thick paste. In the mash tun the malt is mixed with hot water from the boiler C, this water being pumped into the tun by the centrifugal pump E. The pump just mentioned communicates with the boiler C by the pipe *g*, and it delivers the water through another copper pipe, which extends upwards, and is furnished at its upper end with a semicircular bend, as shown in Figs. 1 and 4. This bend is connected to the pipe by a union so that it can be turned round, and made to deliver either into the mash tun A or into the clarifying tun B. The position of the delivery pipe between the two tuns will be seen in the plan Fig. 3.

In the mash tun the malt or "mash" is thoroughly mixed with the water by the mashing machinery shown in Figs. 1 and 3, this machinery, which is on a plan patented by the makers, being specially designed to work up the mash in a vertical direction. It consists of a cast-iron cross frame *c c*, which extends across the mash tun, and carries a bearing for the upper end of the central upright shaft, *c'*, the lower end of this shaft being carried through a stuffing box at the bottom of the mash tun, and being fitted with a bevel wheel, which gears into a bevel pinion on the line shafting, as shown in Figs. 1 and 4. The frame J R, which is mounted on the shaft *c'*, carries, first, a horizontal shaft furnished with crossbars and rakes, *r*, and, second, a vertical shaft carrying two twisted stirrers K. The frame is further provided with a fixed pin or stud, on which are mounted two pinions *q*, these pinions revolving together. The lower and larger pinion of the pair gears into the wheel *p*, at the head of the vertical shaft carrying the stirrers K, and also into another wheel fixed on the main central shaft *c'*, while the upper

pinion *g* gears into a wheel *s*, which runs loose on the central shaft *c'*. This wheel *s* is furnished with a brake disc, surrounded by a brake strap, which can be tightened at pleasure by means of the small pair of bevel wheels and light horizontal shaft, as shown. When the brake is applied—the machine being in gear—the wheel *s* is kept from revolving with the shaft *c'*, and thus, as the upper pinion *q* is smaller than the lower one which gears into a wheel fixed on the central shaft *c'*, the whole frame J R is made to revolve round the shaft *c'*, in the opposite direction to that in which that shaft is moving, while at the same time motion is imparted to the vertical shaft carrying the stirrers K, and the latter are made to revolve in the same direction as the shaft *c'*. If, however, the brake be disengaged, then the whole frame J R moves round with the shaft *c'*, and the stirrers K are then turned by the resistance they meet with in the mash. When the frame revolves in the opposite direction to the shaft *c'* the horizontal shaft carrying the rakes *r* is made to revolve by a bevel wheel at its inner end gearing in a similar wheel fixed on the shaft *c'*.

At the bottom of the mash tun are two valves, through one of which the mash can be run into a pipe which conducts it to the mash boiler C, while the other valve *p* communicates with a pipe leading to the centrifugal pump E, by means of which the mash can be delivered into the clarifying tun as already explained.

To return now to the process of brewing. After the mixing of the mash in the mash tun has gone on for a certain time a portion of the mash is run down into the boiler C, reheated, and is then pumped back through the centrifugal pump E into the mash tun. This process is repeated three times. The mash boiler, it will be noticed, is provided with a central revolving shaft, driven by bevel gear, as shown in Fig. 2, this shaft having a pair of radial arms, which carry movable rakes *e* these rakes sweeping the bottom of the boiler, and preventing the mash from sticking to it. Both the boilers C and D are, as we have stated, heated by direct firing, and both are covered; the covers being provided with manhole doors, and with tubes or funnels for conducting away the steam arising during the boiling process.

After the last portion of the mash has been passed back into the mash tun after reheating, and after this portion has been thoroughly mashed in, the whole quantity is by means of the centrifugal pump E transferred to the clarifying tun B. The bottom of this latter tun is covered by copper plates, placed about $\frac{3}{8}$ in. above the bottom proper, these plates being perforated all over with small holes 1 millimetre ($\frac{1}{25}$ in.) in diameter, there being 10,000 of these holes per square metre of surface, or about 930 per square foot. By means of this perforated false bottom the grains are kept back, and the clear wort is allowed to be drawn off through eight copper pipes—leading from different parts of the bottom, as shown in Fig. 3—into the copper underback or collecting vessel I, whence it is run into the boiling pan D. When the cocks of the eight tubes just referred to are first opened, the wort runs off in a thick condition, but subsequently in a clear state. The first or thick portion is, by means of the small copper pipe shown in Fig. 4, run down from the vessel I to the pump E, and pumped back into the clarifying tun, the subsequent or clear portion being run on to the boiler D, as we have already explained.

When all the wort has been run off the malt or grains are loosened by means of a few turns of the central shaft carrying radial arms or stirrers, as shown in Figs 1 and 3, and this having been done they are watered by means of the revolving sparger L. The weaker wort thus produced is also passed on to the boiler D, and the whole boiled. In order to facilitate the removal of the grains from the clarifying tun a portion of the side of the latter at *u* is made to open so that the grains can be discharged directly into a cart.

In the boiler D the hops are added to the wort, and as soon as the latter "breaks" it is run off through the pipe *y* into the hop-back F. This hop-back is of wrought iron, and in it there are fixed at a distance of from $2\frac{1}{4}$ in. to 4 in. from the sides and bottom strong sheets of brass wire gauze, which keep back the spent hops, but allow the wort to escape through the pipe *i* to

the centrifugal pump G, by means of which it is pumped up into the coolers. The latter do not form part of the apparatus exhibited.

The bevel pinions on the main line of shafting which impart motion to the mashing apparatus and to the stirrers in the clarifying tun, are both connected to the shafting by friction clutches, so that the latter may slip in the event of any unusual strain coming upon the apparatus. The centrifugal pumps E and G are also driven through friction gear, each consisting of an iron cone working on a paper cone, and by raising this shaft carrying the iron friction wheel the pump is thrown out of gear without shifting a belt. The stirring apparatus in the mash boiler C is driven by a belt, as shown, and with the exception of the wort pump G the throwing into and out of gear of all the apparatus, as well as the opening and shutting of the valves for the mash tun is effected from the raised platform or gallery by suitable hand gear. The mash tun and clarifying tun are, as will be seen from the engraving, supported on wrought-iron beams *n* of I section, these being carried on standards or columns, *o*, *o*. The shafting is supported by hangers fixed to cross bearings connecting the beams *n* as shown. Altogether the arrangement is a very neat and compact one, and the details are well arranged to suit the practical requirements to be fulfilled.

The Chemnitzer Maschinenbau Gesellschaft, beside the brewery plant we have described, also exhibited a malt-turning apparatus constructed on the system of Herr A. Von Schlemmer, of Hochheim, shown in Plate 185.

The apparatus was exhibited as applied to a double malt kiln, such a kiln, when constructed on the plans of the makers above-mentioned, in almost all cases admitting of the application of the turning gear.

Referring to Plate 185, it will be seen that the kiln has two floors, one above the other, and that by the side of each are fixed cast iron racks D D. Across each floor there extends a shaft having its end wheels running by the side of the racks D D, and carrying pinions gearing into these racks. Each shaft also carries at its ends, frames, E E, to which chains are attached as shown. The chains it will be seen extend from the winding drums T T on the shaft H, over the pulleys G, to the frames at the ends of the upper shaft A, the line of connexion passing thence around the pulleys G_1 and G_2, to the frames at the end of the lower shaft B, and thence under the pulleys G_3, back to the winding drums T T. The effect of this arrangement is that when the shaft H revolves in the direction of the arrow marked on it in the illustration the shaft A belonging to the upper floor is drawn towards the winding drums, while that B belonging to the lower floor is moved in the opposite direction. On the motion of the shaft H being reversed the shafts A and B are of course drawn in the reverse directions.

As the shafts A and B are drawn backwards and forwards as above described, the pinions they carry, gearing into the rack D D, cause them to revolve, and by thus revolving they continually turn over the malt, the upper shaft A being provided for this purpose with iron paddles, and the lower shaft B with arms tipped with brushes formed of bristles.

The machinery may be driven either by a small separate engine or from an existing line of shafting, and motion is communicated to it by open and crossed belts leading from the pulley *k* to the fast and loose pulleys, O_1 N O_2, the pulley N being the fast one. From the shaft carrying these pulleys the motion is transmitted by a pair of bevel wheels P_1 P_2 to another shaft having fixed on it the spur pinion g_1, this pinion gearing into a spur wheel g^2 on a shaft carrying the worm R. This worm gears into a worm wheel on the shaft H, and thus motion is communicated to the latter and to the winding drums, T T.

The reversal of the motion is effected as follows:—Between the two floors of the kiln is mounted a short shaft forming the fulcrum for a long lever *a*, and having also fixed upon it an arm *b*, which is coupled by the connecting rod *c* to the horizontal bell crank lever *d*. This latter lever is coupled to the slide *e* carrying the belt forks. Thus, according as one or the other end of the lever *a* is struck by the shafts A or B respectively, so the belt forks are shifted, and the crossed belt I, or open belt II, as the case may be, thrown upon the fixed pulley N, and made to drive the gear; the shifting of the belts of course, reversing the motion.

The brackets shown standing up at the side of the floors are provided for the fixing of plates for the better protection of the racks, and if the kilns are very wide the shafts carrying the turning reels are supported at the centre of their length by providing them at that point with a wheel running on a suitable rail. The engraving gives the speeds of the various shafts; but we may add that in arranging this gear the proportions are so arranged that each shaft makes a traverse over its floor in about 15 minutes. The whole arrangement is simple and well worked out, and promises to give satisfactory results in practice.

ARTILLERY AT THE VIENNA EXHIBITION.

THE Vienna Exhibition was very rich in its collections of artillery, for it contained big guns from the Elswick Ordnance Works, Krupp and other German makers, the Russian War and Navy Departments, and Sweden. Moreover, all the above and also several other private makers and foreign Governments sent specimens of field artillery. We propose to review these weapons in succession, beginning with the collection of the Russian Naval Department, which exhibited not only one of the largest guns in the world, viz., a 12-in. piece weighing 40 tons, but also some of the most successfully constructed pieces of lighter ordnance, both in the matters of performance and endurance, which have yet been made.

RUSSIA.

Formerly the Russian Government were in the habit of getting all their artillery from Krupp, but finding that the guns delivered by him were very unreliable, bursting often, and causing widespread distrust and demoralisation amongst the men working them, it was resolved to encourage private makers to set up factories for the purpose of supplying the whole army and navy, and one of these firms, viz., that of Oboukowsky, near St. Petersburg, has manufactured all the cast-steel ordnance which were exhibited. As an instance of the want of confidence which Russia feels in Krupp's ordnance it may be mentioned that three of his 11-in. guns having burst explosively under ordinary service charges, the whole batch of them then in use, were at once discarded and stored away in fortresses, while their places were supplied as rapidly as possible by similar weapons manufactured at Oboukowsky of Tegel steel. Krupp, in answer to the charges brought against him replied that the Russians did not understand how to fire his weapons, but with exactly the same system (the Broadwell) of loading and firing they have got admirable results and endurance from their own home-made guns, one of them, an 8-in. naval gun, having already fired 3,200 rounds, and being still not only fit for, but even employed in further actual service. The 8-in. gun exhibited in the Russian department had fired 1,243 rounds, and looked then as good as new; both these results must be considered very good, when it is known that they were in the habit of throwing the Krupp guns altogether out of service, after they had fired their 999th round.

The Naval Department exhibited five pieces, see Pl. 218, figs. 1 to 11, viz., a 12-in. gun (figs. 12 and 11), weighing 40 tons, an 8-in. gun (figs. 3, 4), weighing 8·754 tons, an 8-in. short gun (figs. 7, 8) or half mortar, weighing 2·9 tons, a 6-in. gun (figs. 5, 6), of 3·92 tons, and a small boat-gun (figs. 9, 10), destined to be used, if necessary, on land, and weighing 7 cwt. In addition to these, the Russian navy possesses 11-in. and 9-in. guns, but owing to the fact that the supply is at present limited, and that all of them now manufactured are employed at present in active service, it was not possible to send specimens of either to the Vienna Exhibition.

The 12-in. gun is the largest piece of naval ordnance in existence, and is perhaps the largest gun, whether naval or land, in the world, if we except the 1,100-pounder weapon, weighing 50 tons, which was made by Krupp in 1870, and sent to Russia, but of the subsequent history of which, nobody has

ever heard anything. It is built wholly of cast steel, and is breech-loading on the Broadwell system; the rifling is polygrooved, with a slow and uniform twist, and the projectile is lead-coated. The inside lining of the bore is one solid tube running from end to end of the gun. It is forged down to 29 in. diameter at the thickest part, and tapers down towards the muzzle. The length of the gun over all is 21 ft., the length of the barrel from the rear of the powder chamber to the muzzle is 18 ft., while that of the rifled portion of the barrel is 13·25 ft. The diameter over the widest ring, viz., the one encircling the powder chamber, is 57·5 in. The interior steel tube is reinforced by four tiers of steel rings shrunk on to the core, but the separate rings of each set, are not welded to each other at their butting ends. The first tier of these rings consists of a series of short cylinders from 10 in. to 12 in. in length, which extend from the breech to the beginning of the chase. These bring the gun up to one calibre in thickness, and from the beginning of the chase to the muzzle, a length of 6 ft. 4 in., the rings are no longer cylindric but are frustra of cones, continued so as to taper uniformly the whole way. The reason why the chase right down its whole length is reinforced with rings contrary to the usual practice is this, that the 11-in. Krupp guns, mentioned above as having burst, nearly all gave way at or near the muzzle. The second tier of hoops extends from the beginning of the chase to the rear of the powder chamber, and brings the gun up to 39·7 in. diameter. Then comes a third tier starting 22 in. short of the second, also continued to the rear of the powder chamber; this tier brings the gun up to 45·62 in. diameter, while lastly comes the fourth set starting 20 in. short of, and continued to the same distance behind as, its predecessor. One of the rings of this tier has the trunnions forged on to it, so that this system of construction avoids the necessity for a separate trunnion ring. The gun has now been brought up to 52 in. diameter, and this is its greatest width except immediately over the end of the chamber, where a single ring 2·75 in. thick and 14 in. long, has been shrunk on. The trunnions are 13 in. diameter, and are situated 8 ft. from the extreme rear end of the gun. The breech extends 3 ft. beyond the end of the chamber, and at its widest part is 36 in. diameter. The breech-loading apparatus is Broadwell's, employed universally by Krupp. It consists of a cylindro-prismatic wedge or breech-piece, moving in a wedge slot made transversely in the breech, at right angles to the bore. This wedge can be withdrawn and inserted by mechanism to be described presently. When withdrawn far enough to leave the passage to the powder chamber clear from behind, a loading cylinder is introduced into the continuation of the bore, and reaches from the end of the gun to within a little distance of the ring provided in the powder chamber for preventing the escape of the gas. This cylinder allows a free and smooth passage for the lead-coated projectile, the protruding rings on which would otherwise grate against and be obstructed by the guide grooves in the wedge slot. The small space between the ends of the loading cylinder and the gas check ring, is provided, in order that any dirt brought out by the sponge in cleaning may escape there, it being very important that all the surfaces in contact be clean, a condition of things which it must be very difficult to maintain in practice. The gas check ring is spherical, fitting into a ring-shaped socket at the base of the powder chamber; the socket has a recess turned at its forward end. The forward end of the ring is turned down thin, and it is made of such a shape that the pressure of the gas tends to expand it outwards and backwards so as to make the joint with the breech piece gas-tight; the rear end is broad, and has two concentric ring grooves turned in it, and is jammed up against the wedge breech piece, or rather against a steel disc let into and projecting a little forward from the wedge. When injured by the action of the hot gases, both ring and disc can be removed and replaced. The mechanism for opening and shutting the breech is as follows:—The wedge, which is prismatic towards the powder chamber and semi-cylindric behind, is provided with two screws for withdrawing or inserting it. The first of these is a quick-motion screw, having several threads turned on it; it works in a nut let into the top of the wedge slot, and the end of the spindle of the

screw is square in section, so that it can be worked with a box spanner provided with a pair of handles. This screw is merely used for moving the wedge quickly in and out after it has been once unlocked and loosened, and it takes the place of the handle by which the breech pieces of guns of less than 8-in. calibre are pulled out by hand. The second screw is used for locking and jamming the wedge. It works into a large cylindrical nut let into a socket made in the broad end of the rear of the wedge. The socket is somewhat longer than the nut, so as to allow of a certain amount of play. The end of the nut, which is flush with the broad end of the wedge, is provided with a fillet or collar, from which projects a stud. Both nut and end of wedge are covered up by a steel plate held in position by screws. The spindle of the screw, which works in the cylindric nut, passes through this plate, and the collar of the screw bears against its under surface. The plate has a sector of a circle cut out of it so as to allow the stud on the end of the cylindric nut a certain amount of play. The foot of the screw projects beyond the nut, and presses against the interior of the wedge itself; the other end of the screw is turned by the same box spanner and handles as are employed in turning the quick-motion screw previously described. But such a screw turning in such a nut might go on working for ever without moving the wedge, unless the nut were by some means engaged with or locked into the body of the gun itself. This is accomplished by making the nut cylindrical in shape, and providing the outside surface with three strong threads which project beyond the socket in which the nut works. In order, however, to allow the wedge to move in and out, these threads had to be chamfered away on the side next the rear wall of the wedge slot, so that the surface of the nut in one position was flush with the surface of the rear of the wedge. Corresponding to these threads on the nut, are three grooves cut in the body of the gun, which are channelled out in the rear of the wedge slot exactly alongside the position occupied by the nut when the wedge has been driven in as far as it will go by the quick-motion screw. When the wedge has reached this position the nut is turned round a portion of a revolution, so that the portion of the threads which have not been cut away may be engaged with the grooves in the rear of the slot; thus the nut is made for the time part of the body of the gun, and is kept fast, and prevented from turning further by the stud on its collar jamming up against the side of the sector cut out of the steel plate mentioned above, which plate acts, moreover, as the bearing for the collars of both the quick-motion and the jamming screws. The turning round of the nut can be accomplished either by the hand acting on the stud on the collar, or else by turning the screw within the nut by means of the spanner transferred from the quick-motion screw; in this latter case it is the friction of the threads in contact with the female screw within the nut, which turns the latter into place. The wedge is thus locked, and cannot now be driven out, but it is not yet jammed home. This portion of the work is performed by turning the screw still further, for the nut being now immovably locked in the body of the gun, the point of the screw on being turned, pushes forward the wedge, and, of course, eventually jams its front face against the face of the ring. In order to open the breech, it is only necessary to turn the screw in the opposite direction, the first result of which operation is to turn the nut back to its first position, where its stud is jammed up tight against the other side of the section in the covering plate. The nut is thus held fast, and by continuing to turn the screw, the collar on its spindle presses up against the steel covering plate, and, of course, forces out the wedge so far as the play between the bottom of the nut and the socket permits. By this time the wedge is fully loosened, and the spanner can be transferred to the quick-motion screw, by which the withdrawal of the wedge is completed. A long experience and extended adoption have proved the merit of this system of breech-loading, and certainly nothing can exceed the ease with which the ponderous wedge of the 12-in. gun at the Vienna Exhibition can be moved, it being quite possible to insert and withdraw it with one hand. This gun had, however, never been fired prior to its appearance at Vienna, which is to be regretted, as no opinion as to its endurance can be given.

The rifling consists of 36 grooves, having a slow and uniform twist. The projectiles, which are all shells, are of three sorts, viz.:—

1. Common cast-iron shells used only for practice in handling the gun.
2. Chilled cast-iron shells with steel points.
3. Cast-steel shells.

The Government had not decided which of the two latter to adopt as the standard armour-piercing projectile. The cast-steel shell is coated with a mixture of lead and zinc, which is arranged so as to have six projecting rings for taking the grooves. This coating is attached to the steel core by a galvanic process, and no trouble has ever been experienced from its stripping. The battering charge consists of 113·8 lbs. of very slow-burning prismatic powder, which it is expected will generate an initial velocity of 1,398 ft. per second. The makers calculate that the resistance of this gun within its limit of elasticity is 4,652 atmospheres.

It is destined for service on board the much-talked-of turret ship, "Peter the Great," and will be worked by a crew of eight men. It is calculated to have cost the Government the enormous sum of 83,000 roubles, or 13,280*l*. The carriage was unfortunately not exhibited, so that we can give no description of it.

When the Russian Government determined on exhibiting the gun, it was a problem with them how to transport it from the factory at Aboukow to the Exhibition at Vienna. As the same problem is likely to be of considerable interest to our own artillerists and railway engineers, the operation as it was carried out may be described; we are indebted to Lieutenant Kolontaeff, of the Imperial Russian navy, for the substance of the following account, and we may add that to him is due the credit of the successful accomplishment of the very difficult undertaking.

The first part of the work was the conveoance of the gun from the works of Aboukow to the railway, a distance of over three English miles by road. This, as may be imagined, was the most difficult part of the whole undertaking for the road was not good, there was a bridge to cross, and a very steep descent to go down. The transit over these three miles occupied six days, and was accomplished as follows:—A travelling railway was first constructed in three separate and independent portions. Each portion consisted of two longitudinal sleepers 60 ft. in length framed together by cross pieces and diagonals. On the top of each sleeper an ordinary railway iron was laid down, and the frame was further provided with three pairs of small rollers, viz., one pair in the middle and one at each end, by means of which it could be moved forwards or backwards. These rollers were mounted not on straight but on cranked axles, the ends of which were prolonged through their bearings, and then attached on either side to wrought-iron levers, by moving which the axles would be turned partly round and the cranked part brought into such a position that the rollers would bear against the ground, or not, as occasion might require. This arrangement was necessary, because, when the gun was travelling over the frame it was obviously important that the latter should bear along its whole surface on the roadway, and when the gun was no longer on that particular frame, the rollers were then useful in transporting it from the rear to the front. This plan was moreover very useful in turning corners or going round curves, for as each pair of rollers could be put independently in or out of gear, it is manifest that in order to go round a sharp corner, it was only necessary to put the central pair in gear, when the frame would be mounted as it were on a pivot, and could be rapidly swung through any required angle; also by putting the central and one of the end pairs in work, it is clear that the wheel base was shortened by one-half, a state of things which enabled curves to be traversed with greater ease. Twenty sailors were employed in manipulating each frame; the gun was mounted on a carriage resting on the rails of the first frame, and the wheels of the carriage were provided with teeth in such a manner that by turning a train of wheel-work in connexion with these latter, the whole gun and carriage could be moved bodily forwards along the rails till it reached the end of the first frame, where it found the second ready to receive

it, and forming a junction with the first. As soon as the gun was fairly on the second frame, the first had its rollers put in gear with the roadway, and was then dragged quickly forwards past the gun, and the two other frames with the third or furthest forward of which it was put in junction. By continuing this operation the gun was got over the whole distance to the railway. There was one bridge to cross, and it was fortunately only a brick arch of from 25 to 30 ft. span. It was strengthened beforehand by propping up the crown of the arch with slanting timber balks which rested at their other ends against the foundations of the bridge. The steep incline previously mentioned was descended by fastening a large ship's anchor into the ground at the top of the hill, and then attaching the carriage to this anchor by means of ropes and pulleys, by which the gun was prevented from travelling too fast over the frames, and thus the whole distance by common road was successfully accomplished.

Two iron trucks, each provided with frames like tenders, and three pairs of wheels, had been built expressly for the railway journey. The springs had all been furnished with compensating levers, so that in case of a bearing running hot, part of the weight on it could be transferred to the neighbouring axle or axles. Including the weight of the trucks, the load on each of the six pairs of wheels amounted to 10 tons. The gun was mounted as follows:—A wrought-iron pivot was fixed to the centre of the platform of each truck, on either side of which, at as great a distance as possible, were fixed three small rollers round an arc of a circle of which the pivot was the centre; the axles of these lay in the direction of the radii of the circle, and they were so arranged that about half of the body of each appeared above the surface of the iron platform of the truck. Each pivot passed into a socket formed in stout block of wood, the top of which was hollowed out so as to form a bearing for the gun, and the two ends were fastened to as many strong iron plates, which in their turn rested on the rollers, so that the plates were formed as arcs of a ring. All this arrangement was provided simply in order that the gun might remain straight while the trucks were passing round a curve, for if the trucks with their six axles and long wheel base, were connected together by the rigid mass of the gun, without any play being allowed for, it is manifest that they could not pass round a curve at all, but with the system of rollers and pivots adopted, perfect freedom of motion in a horizontal plane was allowed for, so that the trucks could move as freely and independently as if there was no connexion between them whatever. The distance between St. Petersburg and Vienna, about 1,157 English miles, was got over in 10 days, eight of which were spent in continuous travelling night and day, during which time neither Lieutenant Kolontaeff nor his small staff could obtain much rest, for at every station they had to get up and inspect the bearings, some of which were continually running hot and giving constant trouble. The two remaining days were spent at the Prussian frontier, in putting new axles and wheels under the trucks, for there is a difference of 4 in. between the widths of the Prussian and Russian railway gauges.

Most of the journey by rail was made with goods trains, but during one whole day the two trucks with their heavy burden were attached to a fast passenger train (German—Courrier Zug), and oddly enough this was the most successful part of the entire transit, for neither the bearings ran hot, nor did any other hindrance occur. The most difficult part of the undertaking was, however, yet to come, for on arriving at Vienna it was found that the general direction of the Exhibition was quite unprovided with special tools and appliances for lifting, although they had previously sent word to St. Petersburg, that they would supply everything of this nature that could be required. The consequence was that Lieutenant Kolontaeff came provided only with a few small screwjacks, and with these he was obliged to push the gun from off the two railway trucks along slides formed of timber beams, and finally with the same tools he had to mount the gun in position, in the separate pavilion erected by the Russian Commission for the War and Navy Departments. Although the distance from the railway to this pavilion is not more than 30 yards, the moving the gun over it occupied ten days, that is to say, as much time as the transit from St. Petersbur to Vienna.

The next largest weapon that was exhibited is the 8-in. gun (figs. 3 and 4), weighing 8·754 tons. It is a great favourite with the Russians, for it has shown immense strength and durability, and it will probably be adopted as their standard medium-sized gun. Like the 12-in., it is breech-loading (Broadwell system); the rifling, also, is polygrooved with a slow uniform twist.

The gun consists of a solid cast-steel core running from end to end of the gun, which at the muzzle is 15 in. in diameter, and at the beginning of the tapering chase is 21 in. The gun is reinforced by a tier of cast-steel rings which reach from the powder chamber to the beginning of the chase, a length of 5 ft. 8 in. This reinforce is not quite parallel, being 29 in. in diameter over the chamber, and only 27 in. over the other end. A third reinforce, consisting of a single ring 33·75 in. in diameter and 11 in. in length, strengthens the rear of the powder chamber. The gun over all is 175 in. in length, of which the bore takes up 151 in., or all but 19 calibres; the rifled portion is 117 in. long and the chase 81 in. The trunnions are 8 in. in diameter, forged on the third ring from the muzzle end of the reinforce, and are situated 69·5 in. from the end of the breech. The breech piece is slightly different from that of the 12-in. gun; like it, it is furnished with two screws, viz., a quick-motion, and a jamming screw, but the nut in which the latter turns is of a different shape, and is locked in a different manner to the other one. In the present case the nut is squared on the rear, and has a recess on that face, into which a bolt can be dropped from the rear of the breech. When this bolt is in place the nut and wedge are both locked, and as the nut cannot revolve, but is held fast and incorporated, so to speak, with the body of the gun, the wedge can be pushed forward and jammed by simply turning the screw; of course the bolt is not so large as the recess, and the amount of play between the two is the measure of the motion given to the wedge by the jamming screw. In order to open the breech, it is simply necessary to reverse the motion of this screw till the wedge is loosened, then to withdraw the bolt into the body of the gun, and finally to withdraw the wedge by means of the quick-motion screw.

The rifling consists of 30 grooves. The projectile is a chilled cast-iron shell weighing 171·2 lbs., and is lead-coated. The charge is 34·3 lbs. of prismatic powder, and the initial velocity is 1443·6 ft. per second.

This gun has fired in all 1,243 rounds, viz.:—

16	rounds	with charges	varying from 14·4 to 22·5 lb.
684	,,	,,	of 28·37 lb.
191	,,	,,	of 29·72 lb.
109	,,	,,	of 31·5 lb.
243	,,	,,	of 34·3 lb.

This latter is the service charge, and it is with it that the velocity of 1443·6 ft. per second has been obtained. The range obtained from this gun with an elevation of 7° 44′, and the service charge was 3,600 yards. The endurance of this gun has been exceeded, as was stated above, by another gun of the same class, which has already fired 3,200 rounds, and is still in active service. It must not be supposed, however, that 1,243 rounds is the limit of the 8-in. gun exhibited, on the contrary it now shows no signs of wear. The resistance of this weapon within its limit of elasticity is stated at 3,067 atmospheres.

Of the same calibre as the gun just described is a breech-loading half mortar (figs. 7 and 8) 89·9 in. long, and 3·21 tons in weight. It is formed of a cast-steel core reinforced with a single tier of rings. The core or central tube is 14 in. thick at the muzzle, and 16 in. thick in the body of the gun. The reinforce is 21 in. diameter at its widest part, but is turned down to 19 in. at the forward end, thus making the gun appear to have two tiers of rings instead of one. As is usual in these weapons, the rear of the powder chamber is strengthened by a single ring shrunk over the reinforce. In the present case this ring is 25 in. diameter and 8 in. long. The trunnions, which are 8 in. diameter, are forged on to a separate ring shrunk over the reinforce; this ring is 26 in. diameter, and is separated by an interstice of 3 in. from the chamber ring, an extraordinary arrangement, which leaves the front of the chamber quite weak compared with either the rear or the part

forward of the chamber occupied by the shot. One would have thought it worth while to have made the ring round the chamber 11 in. long, thus bringing it up to the trunnion ring, and thereby giving the mortar a complete second reinforce 20 in. in length. The bore of this piece is 68·5 in. long, or 8½ calibres, while the rifled portion is 5½ calibres. The breech-loading apparatus is simpler than in either of the two other specimens. It consists of the usual cylindro-prismatic wedge, which, however, in this instance, on account of its lightness, can be withdrawn by hand without the aid of the quick-motion screw. In a slot in the rear face of the wedge is situated a powerful screw with very strong threads turned on it; it projects about one-third of its diameter beyond the sides of the slot, and a corresponding female screw is cut in the body of the breech in the rear face of the wedge slot. By pushing in the wedge by hand, till it is stopped by the threads of the screw coming up against the side of the gun, and then by turning the screw through five or six revolutions the breech can be securely closed; but in order to save time the portions of the threads projecting beyond the sides of the slot are all chamfered away, with the exception of the last turn and a half; the wedge can be then pushed in by hand much further than before, and by turning the screw through one revolution the uncut parts of the thread are caused to enter into the grooves made for them, and the wedge is at the same time driven home and locked; thus we get the benefit of the strength of the five or six turns of the thread, and have only the trouble of putting the screw through one revolution.

The projectile, which is of cast-iron, weighs the same as that of the 8-in. gun, viz, 171·2 lb., but the charge of powder (prismatic) is only about one-half, or 16·2 lb. The initial velocity is not stated, the resistance of the gun within its limit of elasticity is calculated at 2,428 atmospheres.

The next and last gun of large size is a piece of 6 in. calibre, weighing 3·92 tons (figs. 5 and 6). It is 140 in. in length over all, and is formed of a central core and one tier of reinforcing rings all made as usual of cast tegel steel. The core or central tube is 10·25 in. at the muzzle, and 16 in. in the body of the gun. The reinforce, which extends from the rear of the chamber to 55 in. forwards, is 21 in. in diameter at the widest part, and tapers down forward of the trunnions to 20 in.; the last ring is only 18 in. in width. The usual extra ring over the trunnions is 24·2 in. in diameter and 8·5 in. long, and the trunnions themselves are the same diameter as the calibre of the gun.

The barrel is 122 in. or 20⅓ calibres long, of which length the rifled portion occupies 90 in. or 15 calibres. The breech-loading mechanism is precisely the same as that of the 12-in. gun, with the exception that there is no quick-motion screw; the projectile is of chilled cast-iron, and weighs 81·1 lb. It is, of course, like the others, lead-coated. The service charge is slightly over 18 lb. of prismatic powder, and the gun has been fired with 18 lb. of large grain powder; with this charge and the ordinary service shell an initial velocity of 1,597·5 ft. per second was obtained. The pressure on the sides of the gun amounted to 3,000 atmospheres, which is, however, too high a strain for the strength of the weapon; it being only calculated to resist up to 2,957 atmospheres without being strained beyond its elastic limit. The range obtained from this gun with the service charge, and an elevation of 8° 2′, was 2,800 yards.

The 6-in. gun exhibited had already fired 684 rounds, viz., 607 with the service charge of 18 lb. of prismatic powder, 68 with 19·9 lb. of the same powder, and 9 with charges varying from 14·42 to 18 lb. of large grain powder. In every case with the service cast-iron shell weighing 81·1 lb.

The only gun now remaining for description is the little amphibious boat gun (figs. 9 and 10), which is designed for service both on sea and shore. It weighs 792 lb., and throws a shell weighing 12·2 lb. It is formed of a solid cast-steel tube 5·5 in. diameter at the muzzle, and 7·75 in. in the body. The breech is 9·9 in. in diameter, and this thickness is continued for a short distance over the powder chamber, and then suddenly diminishes at the seat of greatest strain to 7·75 in. The trunnion ring has a diameter of 10 in., so that with the exception of the chase, the greater portion of the chamber is the weakest part of the whole gun: an odd arrangement caused by the great

thickness of metal which this system of breech-loading requires. It is undoubtedly of immense convenience that a boat gun should be a breech-loader, and it was a great pity that this advantage was sacrificed in our own boat guns to a fancied gain in the greater simplicity of parts of a muzzle-loader. A muzzle-loader is very difficult to load in a boat, and a breech-loader, on the contrary, exceedingly easy. The breech-loading arrangement in the Russian boat gun is extremely simple, and not at all likely to get out of order. It consists of a prismatic wedge, which is locked and jammed by the same kind of screw as is employed with the 8-in. mortar previously described; the other end of the wedge is made long enough to be bored out to a calibre slightly greater than that of the gun, and when the wedge is withdrawn this bore comes in a line with the barrel, and thus forms a loading cylinder contained in, and forming part of the wedge; when the latter is home and the breech closed, the loading cylinder projects only about $\frac{3}{4}$ in. beyond the side of the gun, and so is protected from any damage. Thus a breech-loading arrangement is obtained which is simple in its parts, no portion of which can be lost, for the wedge cannot be wholly withdrawn from its slot, and all the conditions necessary for a successful breech-loading boat gun are secured.

The service charge is 614·2 grammes, or 21·5 oz. of large grain powder, and the gun has fired 1,034 rounds, viz., 12 rounds before rifling, with charges varying from 215 oz. to 43 oz., and 1,020 rounds after rifling with the service charge. With the service charge and an elevation of 7° 57′ a range of 2,400 yards is obtained.

Germany.

By far the most complete and interesting exhibition of artillery at Vienna was the collection contributed by the firm of Friedrich Krupp, of Essen, on the Rhine. It comprised, in all, 13 pieces, ranging in size from the 30½ centimetre (or 12 in.), down to the little 6-centimetre (2·3622 in.) mountain gun, and each separate specimen was shown mounted on its own proper carriage and slide, except in those cases (such as field-pieces) where this latter forms no portion of the general equipment. Every gun was also accompanied by the ammunition belonging to it, the so-called gunpowder (for it has now ceased to be a powder,) being represented in every case by exact natural-sized models of the charges formed of blackened wood. The whole collection, together with numerous specimens of cast-steel axle tyres and rails, and other specialities of the firm, was exhibited in a separate pavilion behind the centre of the Industry Palace, and between it and the Machinery Hall.

This pavilion and its contents, interesting in themselves, creates naturally an interest in the works at which the exhibits were produced, and, in order to satisfy any desire for information which may arise on this subject, we will begin this notice with a summary account of the establishments of Messrs. Krupp.

The cast-steel works at Essen have been in existence since the year 1810. In the year 1826, the original proprietor, Friedrich Krupp, died, and the management was taken over by his son Alfred, who has continued ever since in possession. To him is due the enormous development and world-wide fame of the works, which, in the month of January of 1873, covered 988 acres; of this latter quantity 185 acres are roofed over. The number of workmen employed is over 12,000, without reckoning some 2,000 who are in the service of the different contractors who undertake the erection of new, and the repair of the old, buildings belonging to the establishment. The different coal and iron mines, and blast furnaces belonging to the firm employ about 5,000 additional hands, which, together with the 739 clerks and other employés, bring the total sum up to very nearly 18,000 souls.

In the year 1872 the quantity of cast-steel produced mounted up to 125,000,000 kilogrammes, or 123,315 tons. The articles manufactured consisted for the most part of plain and cranked axles, tyres, wheels, crossings for railroads, rails and springs, cranked axles for marine engines, different parts of machines, boiler-plate rolls, spring steel, tool steel, guns, gun carriages, and shells, &c.

There are now at work :

Smelting furnaces	250
Reheating „	390
Heating „	161
Puddling „	115
Cupola „	14
Furnaces for different purposes	160
Forges	264
Coke ovens	275
Steam boilers	310

There are 71 steam hammers and 286 engines on the works, the sizes of the former and horse powers of the latter being given by the subjoined Tables. The total power of these steam engines represents 10,000 horses.

STEAM HAMMERS AT HERR KRUPP'S WORKS.

Number	2	1	2	1	5	3	1	7	8	18	2	1	6	2	3	4	1	1	1	1	1
Weight, cwt.	2	3	4	7	8	10	12	15	20	30	60	65	70	75	100	110	140	150	200	400	1,000

STEAM ENGINES AT HERR KRUPP'S WORKS.

Number	3	57	46	16	17	6	1	4	38	4	21	16	3	22	5	2	4	4	2	3	1	5	1	1	3	1
Horse Power.	2	4	6	8	10	12	13	14	16	18	20	23	25	30	35	40	45	60	80	100	120	150	200	500	800	1,000

There are no less than 1,056 machine tools, viz.:—

Lathes	362
Boring and drilling machines	195
Planing machines	107
Punching „	42
Presses	32
Grinding stones	63
Emery polishing machines	31
Tools of different sorts	142

In the year 1872 the consumption of coal amounted to 500 million kilogrammes, or 491,535 tons, while the coke used was 125 million kilogrammes, =123,315 tons. The water for the boilers and other purposes reached the amount of 7,700 million gallons, and the gas, which was made in the establishment, and consumed in 16,500 burners, did not fall far short of 176 million cubic feet. The works are in direct communication with three railroads, viz., the Köln Mindener, the Bergisch-Märkische, and the Rhenish railways. In order to facilitate the traffic between the different shops, there are,—

1. Twenty-three miles of normal gauge railroad, together with 180 sidings, and 39 turntables, the rolling stock consisting of 12 tank locomotives, with cylinders 15·75 in. diameter, together with 530 wagons. Six additional locomotives are being built.

2. Nine miles and three-quarters of narrow gauge line (gauge = ·785 metre) with 147 sidings and 65 turntables. The rolling stock consists of three locomotives, with cylinders 6·18 in. diameter, and 270 trucks. Four additional locomotives are being built.

There are further 272 carts, and in all 191 horses employed in the works; of these latter from 60 to 80 belong to small contractors. In order to regulate the traffic between the different shops there is a telegraphic service with 30 stations. There is a regular fire-brigade of 70 men, who have also the duty of keeping the different yards and shops in order. There are, moreover, 166 watchmen.

So much for the mere technical side of the works, but the social organisation and the institutions founded by the firm in aid of the immense army of

employés in their pay, are hardly less complete. The purport of these institutions may be briefly stated to be the supply of good food, clothing, and lodging, at the cheapest possible rate, together with hospital and medical attendance whenever necessary. With these objects in view, several large marts, managed by the firm, have been founded, at which all the necessaries of life in the way of food and clothing can be had for cost price. At the present time the sum taken in monthly at these establishments is about 75,000 thalers, but owing to their great usefulness and popularity, even this large amount is steadily on the increase. The firm possesses, moreover, one hotel, three beer-depôts, a soda-water factory, and a bakery with two steam engines, which produces on the average about 85 tons of bread per month.

In the way of house accommodation there are already 206 separate lodgings provided for clerks and other office-holders, and 2,948 for workmen; these are at present inhabited by more than 8,000 human beings, but owing to the great demand, the building of new houses is being proceeded with as rapidly as possible. There exist, moreover, already rooms and accommodation for 2,500 unmarried workmen, while in a short time provision will be made for 1,600 more.

There exists a hospital with 100 beds, and an epidemic lazaretto with 120 beds, both of which are under the management of physicians and surgeons provided by the firm. By means of a fund supported partly by the workmen all the subscribers thereto are entitled to free medical attendance for the sum of one thaler a year. There are, moreover, other funds for providing for the sick, for widows, and for all such as have been injured or become unfit for forther work in the service of the firm, which latter adds to this fund the half of all the subscriptions of the individual members. The total income in the year 1872 was 105,035 thalers, the outgoings in the same time reached the sum of 82,632 thalers, while the capital on the 1st of January of this year was 128,992 thalers.

The establishments for education, which form such a remarkable feature in the social organisation of the Creusot works have no necessity here, for the national system of education in Prussia is so perfect as to render any further provision unnecessary.

In addition to the cast-steel factory at Essen, the firm of Friedrich Krupp possesses important coal and iron mines and blast furnaces, which render it independent of the state of the market and the conjuncture of events, and insure a steady and regular supply of the best raw material. The coal mines are four in number, and the iron 414; these latter are found in three districts along the Rhine, and cover in all an area of 49,400 acres.

Lastly, the firm possesses important concessions of excellent iron ore in North Spain. It is intended to import 300,000 tons of ore per annum from this district to convert into cast steel at Essen, and to facilitate the transport 7½ miles of railroad in Spain, together with several steamships, are already being built. The blast furnaces, 11 in number, are distributed in five groups along the Rhine. Two are at Overhammer, which produce 20 tons of spiegeleisen per diem. In connexion with these is a foundry and also a machine shop.

Four more, called the Mülhofer Hütte, are situated on the Rhine, near Engers, and are connected by means of a branch line with the Rhenish Rail way. Three of these are built on the newest pattern, and are furnished with pneumatic lifts. They produce 45 tons per diem of spiegeleisen, and iron suitable for the manufacture of Bessemer steel.

The Hermanns Hütte, also on the Rhine, at Neuwied, has one furnace in work and two others are being built. The Bendorfer Hütte, with one old-fashioned furnace, is at present not in work; while lastly, the Johannes Hütte, at Duisburg, on the Rhine, produces at present from 35 to 40 tons per diem, with four blast furnaces. Six others are now being built. The total amount of pig iron produced by these 11 furnaces does not fall far short of 10 million kilogrammes, or 10,000 tons per months.

Having thus briefly reviewed this great organisation we can turn from the works themselves to their productions in the way of artillery, as they were shown in the Vienna Exhibition. The first object which struck the attention

was an enormous ingot of crucible steel, destined to form the inner tube of a gun 37 centimetres, or 14·57 in. bore. This block weighs 52,500 kilogrammes, or slightly over 51½ tons, and far surpasses in size those which were exhibited on previous occasions, for in London, 1851, the largest ingot shown weighed 2,250 kilogrammes, and was then considered such a wonderful production that it gained the only Council medal awarded to cast steel. In Paris, in 1855, the firm succeeded in turning one out weighing 10,000 kilogrammes; in London, in 1862, a similar one of 20,000 kilogrammes; while in Paris, in 1867, they succeeded in doubling this weight with an ingot of 40,000 kilogrammes.

The block at Vienna was originally cylindric in form, and has been reduced to its present shape under a hammer weighing 1,000 cwt., and will, hereafter be forged under the same hammer to the shape required as inner tube of a gun.

We will now turn our attention to the finished artillery and the carriages, and in treating the subject we will first consider the guns themselves in the order of their size—beginning with the largest—and will afterwards pass on to the carriages.

The largest gun that was exhibited has a calibre 30½ centimetres, or 12 in., and weighs, including the breech piece, 36,600 kilogrammes, or just 36 tons. See Pl. 219, fig. 1. It is formed entirely of Krupp's cast steel, and its construction is the same in principle as that of the Russian gun already described, that is to say, it has one homogeneous tube running from end to end of the gun, reinforced by successive tiers of short rings, on one of which the trunnions are forged; the chase is, however, not strengthened by rings, as is the case with the Russian gun, but consists simply of the prolongation of the inner tube mentioned above.

It is almost needless to remark that it is a breech-loader, the system of closing the breech being the Broadwell cylindro-prismatic wedge, with gas-check ring and plate already described. It may here be remarked that this system of breech-loading is now in general use in the Prussian army, the double wedge plan having been found wanting during the late war. This was especially the case at the siege of Belfort, where after 800 rounds had been fired with 17-centimetre (6·692 in.) siege guns, it was found that the powder gases escaped at the rear in almost as large quantities as at the muzzle, and further firing with heavy charges had to be discontinued. The circumstances in this case were, however, rather abnormal, for the cold was so intense that the ground was frozen to a depth of over 3 ft., and the very cold steel, when suddenly expanded by the action of the hot gases, was fissured all over by a network of minute cracks, which rapidly were eaten out and increased to the size of large channels, which extended right up to the transverse slot containing the breech-loading apparatus, and rendering it impossible to maintain this latter gas-tight. There were, moreover, no skilled workmen at hand to insert a new bush in the base of the bore, which, had it been done, would have completely restored the efficiency of the piece. These are, however, contingencies which must be expected to arise, and the use of a Broadwell ring and plate, either or both of which can be removed and renewed by unskilled men in the space of two or three minutes, has created an entire revolution in Continental breech-loading ordnance. Indeed it is by the adoption of this system that Friedrich Krupp has attained his present eminence as a gun manufacturer. It is stated by those who have worked with the cylindro-prismatic breech closer, both in action and at trials, that if the wedge be taken out, cleaned, and oiled at the commencement of each day's firing, it will, with a moderate amount of care, continue to work well and smoothly for the whole 24 hours.

The following are a few of the principal dimensions and details of the 12-in. gun.

Calibre	12 in.
Total length of gun over all	21 ft. 11¾ in.
Length of bore	18 ft. 11$\frac{11}{16}$ in.
Weight of gun (including breechpiece)	80,520 lb.
Preponderance	0

See Pl. 218, fig. 12.

The bore is rifled with 72 parallel grooves, having a uniform twist of one turn in 71 ft. 5⅞ ins., that is to say, one turn in 71·6 calibres. The powder chamber of this, and in fact of all large guns built on the Krupp system, is slightly eccentric with the bore. The reason is as follows: the chamber is always considerably larger in diameter than the rifled part of the gun, in the present instance it is 12·401 in. against 12 in. The consequence is that the shot bears along the bottom line of this chamber, and is surrounded everywhere else with a certain amount of windage, its axis is likewise parallel to but below the axis of the bore. When the shot is moved forward by the pressure from behind, the foremost end is the first to rise into the narrow rifled part of the bore, the rear end still bearing on the bottom of the chamber. The consequence is that the axis of the shot is now inclined to the axis of the bore, and the lead coating, as may easily be seen, does not take kindly to the grooves, but bears much harder against the extreme top and bottom, thus injuring the accuracy of the shooting, and also leaving a space where the powder gases can get in between the shot and the surface of the bore, and destroy the latter by the process of erosion. All these difficulties have been obviated by raising the chamber slightly, so as to bring the axis of the projectile strictly into line with the axis of the gun. This plan has been adopted with equally good results by the Russians also; in fact, the eccentricities of the chamber may be clearly seen by referring to the drawings of these guns (Pl. 218, fig. 12). The projectiles used are two in number, namely:—

1. A steel shell for use against armour plates weighing 296 kilogrammes, or 651·2 lb., which with a charge of 60 kilogrammes, or 132 lb., attains an initial velocity of 465 metres, or 1,525 ft. per second, and,

2. A cast-iron shell weighing 257 kilogrammes = 565·5 lb., which with a charge of 50 kilogrammes = 110 lb., attains an initial velocity of 1,509 ft. per second.

The powder is prismatic, and for guns of 10·23 in. calibre and upwards, has a specific gravity of from 1·72 to 1·76, while for smaller guns the specific gravity is from 1·62 to 1·66.

The steel shells are very remarkable, being formed of cast steel forged, with the cavity for the bursting charge also forged in them. There were several specimens in the pavilion cut in two, so that the workmanship of the cavity may be inspected, and certainly nothing could be more perfect. The process of manufacture is, however, kept secret. The price, far from being high, as one might naturally expect, is not greater for large calibres than the ordinary chilled iron projectiles, while for small calibres the difference is but slightly in favour of the latter material.

A 12-in. gun, of exactly the same make as the one just described, was tested for endurance in the month of February 1873, before a Commission of Prussian and Austrian artillery officers with the following results:—

In all 230 rounds were fired with varying charges, of which

Rounds		Lb. charges.
5	were with	44
7	„	88
6	„	110
207	„	130
5	„	143

In every case with prismatic powder and shot weighing from 660 to 671 lbs. The gun was quite uninjured, with the exception of that part of the chamber occupied by the projectile, which was slightly burned. The trials will be continued as soon as Krupp's new shooting range, 23,000 feet long, is provided with the necessary arrangements. The gun is destined for coast defence, and is mounted for this purpose on a carriage and slide, which will be described in detail hereafter.

The next largest piece, as far as calibre is concerned, was a 28-centimetre = 11·0239 in. howitzer, or half mortar, also mounted on a coast carriage. See Pl. 221, figs. 1, 2, and 3.

It is much to be regretted that no 11-in. full-sized gun was exhibited either by Krupp or Aboukow, for up till now these calibres have been the largest in

the Russian and Prussian services, and have been made the subjects of very careful and interesting experiments. The 11-in. piece shown at Vienna is intended to be fired at very high degrees of elevation, as much as 75 deg. being possible. It is also a cylindro-prismatic breech-loader, though when fired at high degrees of elevation the wedge cannot be withdrawn or the charge inserted without turning the gun on its trunnions through a very considerable angle. This inconvenience is caused by the rear end of the piece, at high angles, coming between the sides of the carriage, which leave no room for the withdrawal of the breech piece. The following are a few of the principal dimensions :—

Calibre	11 in.
Length of gun over all	10 ft. $5\frac{15}{16}$ in.
Length of bore	7 ft. $3\frac{1}{8}$ in.
Weight of gun, including breech-piece	22,000 lb.
Preponderance	0

The gun is rifled with 72 parallel grooves, the projecting portions, or "lands," being 1·771 ins. in width. The twist is uniform, and makes one turn in every 36 ft. $8\frac{15}{16}$ in. or 40 calibres.

The projectile consists of a long cast-iron shell, weighing 437 lb. when loaded, and the maximum charge is 44 lb. of prismatic powder. The structure of the gun is the usual solid steel core reinforced by rings. All details of range, initial velocity, and endurance, were wanting for this piece.

The next gun to be described is a short 10·19 in. naval gun, mounted on a battery carriage. See Pl. 220, fig. 3. It is one of the few Prussian guns of the performance of which we possess authentic information; for on the 15th of August 1872, it was tried at Tegel against armour plates together with the 28-centimetre (=11 in.) gun, and the results of these experiments are embodied in a report made by Lieutenant-Colonel Reilly to the Surveyor-General of the Ordnance.

The following are the principal dimensions : —

Calibre	10·19 ins.
Length of gun over all	17 ft. $\frac{11}{16}$ ins.
Length of bore	14 ft. $5\frac{1}{16}$ in.
Weight of gun including breech-piece	39,600 lb.
Preponderance	0.

The bore is rifled with 64 parallel grooves, the lands being 1·791 ins. wide, and the twist, which is uniform, makes one turn in 59 ft. $8\frac{1}{2}$ ins., or 65 calibres.

The weight of the loaded steel shell is 184 kilogs. (=404·8 lb.), and the initial velocity, with a charge of 37·5 kilogs. (82·5 lb.), is said to be as high as 450 metres (or 1,476 ft.) per second. In addition to the above there is a cast-iron shell weighing 159 kilogs. (=349·8 lb.) which attains the same velocity with a charge of only 30 kilogs.

In the experiments at Tegel referred to above, the 10·19 ins. gun was not precisely the same as the one just described. It belongs to a class called the long 10·19 ins. gun, and differs from the other, chiefly in the length of bore and the weight of the whole piece; it will, nevertheless, serve perfectly as a standard for comparison, and consequently we extract the following details of the performance from the report of the trials.

The target was composed of 3 plates, respectively 9 in., 10 in., and 12 in. in thickness, each of them being 16 ft. long by 4 ft. 4 in. high. They were made by Brown and Co., of Sheffield, and the backing consisted of two layers of 9-in. oak beams, with an inner skin $\frac{5}{8}$ in. in thickness. The 10·19 ins. gun used had a length of bore=16 ft. 2 $\frac{7}{16}$ in. against the 14 ft. $5\frac{15}{16}$ ins. of the corresponding piece at Vienna. The twist of the rifling, which was uniform, was one turn in 70 calibres. The range was 150 metres = 164 yards, and the velocity was taken at a distance from the muzzle of 50 metres = 55 yards. The following are the details of the three most interesting rounds :—

Charge	32 kilogs. = 70·5 lb.
Elevation	30 min.
Weight of projectile	188 kilogs. = 414·5 lb.
Velocity	418 metres = 1371·4 ft.

The shot penetrated the 10-in. plate, its point entering above 7½ in. into the backing and bulging out the skin to the extent of nearly 6 in. The head of the shot remained in the plate, while the end, which was broken off nearly level with the face of the target, was shivered into many pieces, some of which were picked up in front. The projectile, which was a Gruson chilled shell filled with dried peas, was considered to be of inferior quality.

In the next round fired with this gun the charge and elevation were the same as before, while the projectile weighed 187·95 kilogs. = 414·3 lb., and the velocity = 408 metres or 1338·6 ft.

The target was the same as before, and although the velocity was some 10 metres less, nevertheless the shot made a clean hole through both plates and backing, and then broke up, the head, weighing 176 lb., being picked up 180 yards in the rear, and a part of the base remained in the shot hole.

The third and last round was fired at the 12-in. plate under the following conditions :—

Charge - - -	33 kilogs. =	72·7 lb.
Elevation - - -	28 min.	
Weight of projectile -	187·75 kilogs. =	413·8 lb.
Velocity - - -	421·8 metres =	1376·7 ft.

The shot made a hole right through the 12-in. plate ; its point penetrated to within 2·2 in. of the skin, while the cylindrical portion remained firmly fixed in the plate.

Leaving the first unlucky round out of consideration, the committee who carried on the experiments came to the conclusion that the 26-centimetre gun could penetrate the 10-in. plate at a range of 1,470 feet, and the 11-in. plate at 492 feet. They were also of opinion that an augmentation of the velocity by 50 feet would enable it to penetrate the 12-in. plate. This augmentation of the velocity has already been obtained, and more than obtained ; for, if the statement made by Mr. Krupp in his catalogue be taken as authentic, the initial speed is now 1,476 ft., a result which is due to the increase of the powder charge by 10 lb. The weight of the projectile remains nearly the same, so that under the circumstances the short 10·19 in. gun must be considered as an exceedingly powerful weapon.

The next largest guns exhibited were a long 24-centimetre, and a long 21-centimetre (respectively 9·449 and 8·2679 in.). See Plates 219, 220. These weapons are both of peculiar interest in the history of the development of the Krupp system of heavy artillery, for they must be looked upon as the direct offspring of the famous trials at Tegel, in 1868, the history of which, written by the late Captain von Doppelmair, of the Russian Imperial Guard, has provoked (we think unjustly) a considerable amount of ill feeling at home. For a detailed account of these experiments, we must refer our readers to the pamphlet referred to above, and also to the very polemic reply written to it by Captain Majendie, R.A. For the present we shall extract such information regarding facts as may be interesting to our readers, taking care to notice especially such points as may bear on the modifications rendered necessary by the results of the trials.

The occasion of the experiments was the continually increasing strength of armour-plated ships, which rendered it absolutely necessary to provide guns of corresponding power. Having had little experience of such heavy ordnance, it was arranged that Krupp should provide two experimental 24-centimetre, and also two 21-centimetre pieces which were to be tried both for accuracy, durability, and penetrative power, with a 9-in. Woolwich gun, which was purchased by the Prussian Government for the purpose.

The 24-centimetre weapons were as usual formed of a solid central tube reinforced by two tiers of rings, and were provided with the cylindro-prismatic breech-piece. One of them was provided with a Broadwell ring, and the other with a copper cup for checking the escape of the gas. Of the two 21-centimetre guns one was light, while the other, formed entirely of solid steel without rings, was considerably heavier, and the breech was closed with the double wedge apparatus.

The most important dimensions are given in the annexed Table : —

	9·449 in. Calibre (1.)	9·449 in. Calibre (2.)	Heavy; 8·2679 in. Calibre.	Light; 8·2679 in. Calibre.
Calibre - - -	9·449 in.	9·449 in.	8·2679 in.	8·2679 in.
Length of bore - -	13 ft. 1½ in.	13 ft. 1½ in.	10 ft. 11½ in.	10 ft. 11½ in.
Length of the rifled part.	9 ft. 6½ in.	9 ft. 7$\frac{3}{16}$ in.	8 ft. 4 in.	8 ft. 9$\frac{5}{16}$ in.
Length of chamber -	3 ft. 6¼ in.	3 ft. 6¼ in.	2 ft. 6$\frac{7}{16}$.	1 ft. 11$\frac{1}{16}$ in.
Length of gun over all	15 ft. 5$\frac{7}{16}$.	15 ft. 5$\frac{7}{16}$ in.	12 ft. 10$\frac{3}{16}$.	13 ft. 4$\frac{3}{16}$.
Rate of twist. One turn in metres.	45 ft. 9$\frac{5}{8}$ in.	49 ft. 11$\frac{5}{8}$ in.	40 ft. 6$\frac{9}{16}$.	40 ft. 6$\frac{9}{16}$.
Number of grooves -	32	32	30	30
Weight of gun and breechpiece.	32,230 lb.	32,230 lb.	19,800 lb.	14,850 lb.
Weight of chilled projectile (Gruson's.)	335·5 lb.	335·5 lb.	220 lb.	220 lb.
Weight of lead coating	62·70 lb.	62·70 lb.	48·4 lb.	48·4 lb.
Maximum charge of powder.	46·2 lb.	46·2 lb.	24·2 lb.	19·8 lb.

The powder used was the ordinary Prussian cannon powder. The first experiment was made in order to obtain the initial velocities of the separate pieces. For this purpose one of Le Boulengé's chronographs was used at a distance of 154 ft. from the mouths of the guns. The best result for the 24-centimetres was obtained with a charge of 46·2 lb., the corresponding speed being 1140 ft. With the heavy 21-centimetres, a velocity of 975 ft. was registered, the charge being 24·2 lb., while for the light 21-centimetres the velocity was 1036 ft., and the charge 19·8 lbs.

After having been satisfactorily tried for accuracy, they were next fired at ec targets, of which,

No. 1 represented the armour of the Prussian ship Friedrich Karl, and consisted of three plates, of which the upper one was 5 in. thick, and the two lower ones 6 in. The backing consisted of balks of teak 10 ins. square. At the back of each plate was a wrought-iron girder situated between two adjacent balks of teak, while the backing consisted partly of single and partly of double plates an inch in thickness.

Target No. 2 was covered with three plates, each 7 in. thick, the backing being formed of three layers of teak and oak, making up in all a thickness of 29 in.

Target No. 3 was also covered with three plates, of which the two uppermost were 8 in., and the remaining one 9 in. in thickness. The backing was a single 10-in. layer of teak. Behind each plate were two wrought-iron girders. The skin consisted of two $\frac{3}{4}$-in. plates.

The result of the firing, which was eminently unsatisfactory, may be briefly summed up as follows : —

The 21-centimetre gun could not effect the penetration of the 5 in. plate at the distance of 3,000 ft., while at the same distance the 24-centimetre only just got through the 6 in. plate.

At 2,345 ft. range the 24-centimetre could not get through the 7-in. plate, and at 1,541 ft. it proved itself absolutely useless against the 8-in. plate.

These being the results, it was rightly deemed necessary to increase the initial velocity by every possible means. The means at hand were three in number :

1. To increase the charge of Prussian cannon powder.
2. To lessen the resistance of the rifling.
3. To use a quicker burning, and more violent powder.

By increasing the charge up to 55 lb. for the 24-centimetre gun an initial speed of 1,189 ft. was obtained. The shooting, however, with this charge was very erratic, so that 49·5 lb. was finally chosen as the maximum, the corresponding velocity being 1,151 ft.

The practice with the 21-centimetre gun was improved by the increased charge of 26·4 lb., but after six rounds the foremost of the two wedges broke, and it was necessary to fall back in consequence on the original charge

of 24·2 lb. Thus the first attempts at increasing the speed proved ineffectual, and the second efforts were even more so, for no good results whatever were obtained by diminishing the resistance of the rifling.

It remained only to try a violent gunpowder. This was accordingly done, for a comparison was made between 42·9 lb. of English L.G.R. and the same quantity of ordinary Prussian powder. The following was the result:—

	Feet.
With the English powder a velocity of - -	1,161
„ Prussian „ „ - -	1,100

The gun (24 centimetres, No. 2) was, however, very much injured by the use of the English L.G.R., for two rents made their appearance in the gas-check recess, and the metal of the wedge behind was very much bent. Thus the result of these trials may be said to have been *nil*, for the initial velocities remained unaltered, and things were in this state when the first comparative trial was made between the Krupp and Woolwich guns. This latter weapon is too well known to need description here. We will therefore merely mention that the loaded shell (Palliser's) weighs 250 lb. and that the initial velocity as stated by the Prussians was 1,325, though in English tables it is put down at the much higher figure of 1,417 ft. The result of the experiment was the complete triumph, so far as penetration is concerned, of the English gun, for Target No. 1 with the 6 in. plate was completely penetrated at the distance of 3,083 ft., as also was Target No. 2 with the 7-in. plate at 2,345 ft., and Target No. 3 with the 8-in. plate at 1,541 ft. Whereas the German 24-centimetre gun behaved just as before, *i.e.*, barely got through the 6-in. plate, and was absolutely impotent against the others. These results were difficult to explain, for comparing the energies per square unit of section of the two projectiles, we find them to be as 1 to 1·06—a difference which is not nearly enough to explain away the vast superiority of the Woolwich gun. It was necessary to look elsewhere for a reason, and the Committee eventually came to the conclusion that the absence of penetrative power on the part of the German guns was due entirely to the heavy lead coating which surrounded their projectiles, and also to the shape of the heads of these latter. It was observed that when one of these lead-coated shots struck the target, either the lead was entirely stripped off by the shock, thus depriving the projectile of the force due to its weight, or else, if it remained on the shot on its passage through the hole, it was retarded by the lead jacket getting caught in the jagged edges of the hole, so that a considerable portion of what should have been force of penetration was consumed in deforming and tearing the material of the projectile itself. In the case of the lead jacket being wholly stripped off by the shock of impact, Captain von Doppelmair was of opinion that the penetrative power of the projectile should be estimated on the supposition that its weight was equal only to that of the cast iron or steel portion. He accordingly estimated the energy per unit of section on this supposition, and comparing the result with the similar calculation made for the Palliser shell as fired from the Woolwich gun, he found the ratio of the results to be as 1 to 1·30, a preponderance in favour of the Woolwich system which was quite sufficient to account for its great superiority. The fault of the shape of the heads of the projectiles was soon removed by casting new ones, which were very close imitations of Palliser's, but the disadvantages due to the lead jacket have never been wholly got over up to this date. It is true that Krupp has succeeded in lightening the weight of the lead very materially by distributing it in rings over the body of the projectile instead of covering the latter with a solid cylinder, as was formerly the case, and he has thereby diminished the amount of the evil, but the evil, such as it is, still remains, and was noted and commented on by Colonel Reilly last autumn in the report mentioned above.

At present German artillerists are seeking to do away with lead altogether, by substituting for it copper rings, and it is reported that, with calibres up to 6-in., very favourable results have been obtained. The trials with still larger guns are now progressing, but no authentic reports of the results have yet been written, and, consequently, all details, except mere hearsay rumours, are at present wanting.

Referring again to the Tegel trials, we find that the Krupp system appeared

to have wholly failed; when it was determined, as a last resort, to try the new prismatic powder, which had given good results in Russia. In consequence the breech-piece of one of the 24-centimetre guns was arranged for central firing, and experiments for initial velocity carried out, the result of which is given in annexed table.

Weight of Charge. Prismatic Powder.	Weight of Projectile.	Initial Velocity.
pounds.	pounds.	feet.
46·2	335·50	1,198
49·50	335·50	1,144
52·8	335·50	1,286
52·8	294·80	1,365
52·8	275·00	1,412

These results were eminently satisfactory, and put the Krupp gun again in a position to compete with the Woolwich system. Accordingly, after some very favourable preliminary trials to test the accuracy of shooting with the new powder, a second comparative trial was made between the two guns against armour plates. The results may be briefly stated as follows :—

The Krupp gun, with a charge of 52·8 lbs., effected the penetration of the target with the 8-in. plate at a distance of 1,541 ft., not only with the heavy Gruson chilled projectile, but also with the lighter steel shell manufactured by Krupp, the heads of both being fashioned after the Palliser pattern, and the initial velocities being respectively 1,286 and 1,414 ft.

The Woolwich gun, with a Palliser chilled shot weighing 249·70 lbs., and the ordinary charge of L.G.R. powder, penetrated the same target just as easily, but did not make quite so large a hole.

When fired against the 9-in. plate, the Krupp steel shell penetrated the plate itself, and further entered the backing to the extent of $5\frac{3}{8}$ in., while the Palliser shot fired from the Woolwich gun pierced the same plate and entered the backing to the depth of $4\frac{1}{8}$ in. Thus the performance of the two guns was practically the same, a result which cannot be considered satisfactory to lead-coated projectiles, for the energy per unit of section of the latter compared with the same figure for the English guns, was as 1·15 and 1·17 to 1, from which we should have been led to expect much greater penetration on the part of the Krupp gun. The only other one of this series of experiments to which we shall allude is an attempt which was made to improve the 21-centimetre gun. The double wedge having signally failed to stand the effect of heavy charges, two new pieces, of 21-centimetres calibre each, were manufactured for trial, and both of them were provided with the Broadwell cylindro-prismatic wedge. One of them was a solid steel gun, while the other was strengthened with rings, and weighed about 19,800 lbs. The ringed gun differed from the solid one, and also from all previously manufactured pieces of 21-centimetres, in having a chamber increased in length to the extent of $5\frac{7}{16}$ in., and also in having the rifled portion of the bore lengthened by $14\frac{5}{8}$ in. The first trials were made to find the initial velocities. These are given below.

1. The long ringed gun.

Charge of Powder in Pounds.	Weight of Projectile.	Initial (Average) Velocity.
Prismatic powder.	pounds.	feet.
37·4	220	1,379
33·0	,,	1,292
27·5	,,	1,159
22	,,	1,024
Ordinary Prussian powder		
27·5	,,	1,142
22	,,	1,034

The result of shooting with a light steel shell and 37·4 lb. of prismatic powder was an average initial velocity of 1,476 ft. per second.

2. The short solid gun.

Charge of Powder, Pounds.	Weight of Projectile, Pounds.	Average Initial Velocity, Feet.
28·6	220	1,228
26·4	—	1,172
24·2	—	1,109
22·0	—	1,048

For the sake of comparison we also give the velocities obtained from the solid 21-centimetre gun with varying charges of ordinary Prussian gunpowder :—

Charge of Powder in Pounds.	Weight of Projectile, Pounds.	Average Initial Velocity, Feet.
19·8	220	998
22·0	—	1,042
24·2	—	1,075
26·4	—	1,094
27·5	—	1,103

It will be seen at once from these three tables what the advantages are of using prismatic powder, especially in heavy charges. The results were so satisfactory that it was determined to try the two guns against armour plates. The 21-centimetre piece was first experimented with. The lessons taught by this trial may be summed up in a few words. At the distance of 492 ft., the Gruson chilled shells, weighing 220 lb., could not quite penetrate target No. 1 with the 6-in. plate, the charge being 11 kilogs. of either kind of powder. With all conditions precisely the same, excepting that the charge was increased to 28·6 lb. of prismatic powder, the gun succeeded in easily penetrating this same target with the 6-in. plate. With 27·5 lbs. of the same powder this target was likewise penetrated, while with 28·6 lb. and the same sort of projectile, target No. 2, with a 7-in. plate, was clean shot through. 27·5 and 28·6 lb. of prismatic powder were consequently adopted as the service charges for this gun.

The ringed 21-centimetre piece was next tried against target No. 3 with 8-in. and 9-in. armour plates, at a range of 1,541 ft. 37·4 lbs. of prismatic powder were used as charge, and the projectiles were Gruson's 220 lb. chilled shell, which attained an initial velocity of 1,377 ft., and also Krupp's steel shells, weighing 192·50 lb., the initial velocity of which reached the high figure of 1,476 ft. The results of the trial were very satisfactory. The chilled shell got through the 8-in. plate, and the backing behind it, with as much ease as the projectile from the 24-centimetre with 24-kilog. charge had previously done. The 9-in. plate was also penetrated to the same extent as it had been before by this latter weapon. The Krupp cast steel showed itself inferior to the Gruson chilled cast-iron shell.

In consequence of the information thus gained, the committee recommended that all the heavy 21-centimetre guns in the Prussian service should be strengthened by a tier of rings, and be further provided with the Broadwell breech-loading system, in order that they might be made capable of receiving service charges of 33 and 37·4 lb. A new ringed 21-centimetre-piece was also ordered with a slower twist, namely, one turn in 70 calibres, in order to obtain more accurate shooting with heavy charges.

We have now done with these Tegel trials so far as they bear on the matter in hand. It is perfectly evident, without further comment from us, how completely the information there attained has influenced the whole of the Prussian heavy artillery; not only were the shape of the projectiles and the nature of the breech-loading determined thereby, but also by the successful introduction of prismatic powder, every single detail of the gun from the

thickness of the metal down to the length of bore and rate of twist were completely modified.

We can now proceed to describe the 24-centimetre and 21-centimetre guns that were exhibited in the Krupp pavilion. See fig. 2, Pl. 219, and figs. 1, 2, Pl. 220.

The following are the principal dimensions :—

Calibre - - - -	9·252 ins.	8·228 ins.
Length of gun - - -	17 ft. $1\frac{7}{8}$ in.	15 ft. $5\frac{3}{16}$ ins.
„ bore - - -	14 ft. $9\frac{9}{16}$ in.	13 ft. $5\frac{9}{16}$ ins.
Weight of gun including breech-piece	34,100 lb.	22,000 lb.
Preponderance - - -	0	0
Number of grooves - -	32	30
Twist—one turn in metres - -	54 ft. $\frac{1}{2}$ in.	43 ft. $4\frac{7}{16}$ ins.
Weight of loaded shell - -	297 lb.	209 lb.
Charge for the same - - -	52·8 lb.	37·4 lb.
Initial velocity of the same - -	1,410 feet.	1,410 feet.
Weight of cast-iron shell - -	260·70 lb.	173·8 lb.
Charge for „ „ - -	44 lb.	30·8 lb.
Initial velocity of „ - -	1,391 feet.	1,410 feet.

The twist of the rifling in both these guns is, as usual, uniform. The grooves, however, have not parallel sides, for the widths of the lands are, for the 24-centimetre gun, 1·535 in. behind, and ·309 in. in front while for the 21-centimetre piece the corresponding figures are respectively 1·299 in. and 2874 in.

The second 21-centimetre gun exhibited is destined for siege purposes, and as such it is of course extremely light, weighing only 8580 lbs. Its length over all is 11 ft. $1\frac{13}{16}$ in., of which the bore occupies 9 ft. $6\frac{1}{2}$ in. The rifling has 30 grooves, with a uniform twist of one turn in 40 ft. $6\frac{9}{16}$ in. See fig. 2, Pl. 220.

The weight of the loaded cast-iron shell is -	173·8 lbs.
The weight of the charge of prismatic powder	14·3 „
Initial velocity of the shell - - -	984 ft.

This gun is mounted on a very beautiful carriage and frame, which will be noticed at some length hereafter.

The remaining seven guns that were exhibited are of considerably less interest, both on account of their comparatively small size, and also because we have no details of their performance. The new experimental $3\frac{1}{2}$ in. field gun, which is probably the most powerful weapon of its class in the world, was not shown at all. We shall consequently content ourselves with the following table of dimensions, &c.

Name and Nature of Gun.	Long 6·692 in. Gun.	5·905 in. Gun.	Long* 5·905 in. Gun.	4·724 in. Gun.
Calibre - - -	6·692 in.	5·905 in.	5·905 in.	4·724 in.
Length of gun - -	13 ft. $11\frac{1}{4}$ in.	11 ft. $3\frac{3}{8}$ in.	12 ft. $7\frac{1}{3}$ in.	9 ft. $7\frac{1}{16}$ in.
Length of bore - -	12 ft. $4\frac{3}{4}$ in.	9 ft. $11\frac{5}{8}$ in.	11 ft. $2\frac{15}{16}$ in.	8 ft. $6\frac{3}{8}$ in.
Weight of gun, including breech-piece.	12,320 lb.	6,600 lb.	8,800 lb.	3,080 lb.
Preponderance - -	0	55 lb.	165 lb.	220 lb.
Number of grooves -	48	36	48	18
Twist, one turn in metres.	36ft. $8\frac{15}{16}$ in.	31 ft. $9\frac{7}{8}$ in.	31 ft. $9\frac{7}{8}$ in.	27 ft. $7\frac{7}{16}$ in.
Weight of loaded steel shell.	121 lb.	—	77 lb.	38·5 lb
Weight of charge for ditto.	26·4 lb.	—	17·6 lb.	7·7 lb.†
Initial velocity of ditto	1,509 ft.	—	1,409 lb.	1,476 lb.
Weight of loaded cast-iron shell.	99 lb.	61·6 lb.	61·6 lb.	36·3 lb.
Weight of charge for ditto.	22 lb.	13·2 lb.	14·30 lb.	6·6 lb.
Initial velocity of ditto	1,525 ft.	1,542 ft.	1,525 ft.	1,476 ft.

* See fig. 3, Pl. 219. † Large grained powder.

Table—*continued.*

Name and Nature of Gun.	3·543 in.* Field Gun.	3·149 in. Field Gun.	2·362 in. Mountain Gun.
Calibre	3·543 in.	3·149 in.	2·362 in.
Length of gun	6 ft. 8½ in.	6 ft. 4$\frac{3}{16}$ in.	4 ft. 1½ in.
Length of bore	5 ft. 11$\frac{3}{4}$ in.	5 ft. 8 in.	3 ft. 8½ in.
Weight of gun, including breech-piece.	935 lb.	649 lb.	235·4 lb.
Preponderance	110 lb.	154 lb.	30·8 lb.
Number of grooves	16	12	18
Twist, one turn in metres	18 ft. 1$\frac{5}{8}$ in.	11 ft. 10$\frac{7}{16}$ in.	6 ft. 10$\frac{5}{8}$.
Weight of loaded steel shell	—	—	—
Weight of charge for ditto	—	—	—
Initial velocity of ditto	—	—	—
Weight of loaded cast-iron shell	15·18 lb.	9·46 lb.	5·06 lb.
Weight of charge for ditto	1·32 lb. †	1·10 lb. §	·44 lb.
Initial velocity of ditto	1,056 ft.	1,191 ft.	984 ft.

Krupp's Gun Carriages.

The collection of gun carriages and slides exhibited in the Krupp pavilion was hardly less remarkable in its way than were the thirteen pieces of artillery already described, for in nearly every one of them there was some peculiarity worthy of notice; in some there are quite new features introduced, while the workmanship in every case is perfect enough to satisfy the severest critic. It should, however, be stated here, that in 1870, Krupp's gun carriages were, as a rule, copies, down to the minutest details, of the carriage supplied by Sir William Armstrong for the legal experiments. We propose, therefore, to give an account of each carriage and slide in detail, beginning with the largest and continuing in the same order as we did with the guns; but it should first be mentioned that the material generally used in their construction is wrought iron, only individual parts, such as axles, shafts, cylinders, and piston rods for hydraulic brakes, the slide rollers of the coast carriages, &c., consist of steel. Cast iron is only used in very small wheels.

The great 12 in. gun is mounted on a carriage and slide for coast defence, which are so constructed as to permit of firing over breastworks 1·9 metres (=6·24 ft.) in height. The height of the trunnion centre above the ground is consequently 7 ft. 9$\frac{5}{8}$ in.

The sides of the carriage proper are each made of two solid plates set about 5 in. apart, and joined together all round the outer edge by a ⌐¬ shaped bar. Usually the lower surfaces of these sides rest flat on the upper surface of the slide, but in order that the gun may be easily run in on the slide, otherwise than by the force of recoil, four rollers are fixed to the carriage, the two hindermost of which have eccentric axles, which can be brought into operation by turning them by means of a lever through a fraction of a revolution.

Attached to the upper surface of the slide behind each side of the carriage, are two wedge-shaped rails, the points of the wedges being immediately behind and underneath the two eccentric rollers. When the gun recoils, the carriage, of course, begins moving up these rails, the eccentric rollers commence to bear at once; the under surface of the carriage is consequently lifted up from contact with the slide, and the foremost rollers on the other hand come into contact with the slide. The consequence is, that when the recoil is finished, the gun and carriage are at liberty to roll freely down the wedge rail; as soon, however, as they leave this rail, both sets of rollers cease to bear, the under surface of the carriage again comes into contact with the slide, and the friction, thus generated, quickly brings the gun to, any small residual shock being taken up by the buffers fixed to the front end of the slide. The requisite elevation between the ranges + 17 deg. and − 7 deg. is

* See fig. 3, Pl. 229. † Common Prussian gunpowder

obtained as follows: To the body of the gun itself are fixed two segments of toothed wheels or circular racks, the centre of curvature being the axis of the trunnions; one of these racks is fixed on each side of the gun underneath, and they are each set in motion by a train of toothed wheels, the bearings of which are in the sides of the carriage; the first wheel on either side, *i.e.*, the one to which the power is applied, has its spokes projecting beyond the rim so as to serve as handles, precisely after the fashion of a steering wheel; the two of them are fixed to one through-running axle, so that, if necessary, the elevation can be given from one side only, the axles of the two last wheels, *i.e.*, the two which engage with the circular racks, have locking nuts with handles fitted to them, which being jammed up against the wheels serve as brakes to keep the gun fixed at any given angle of elevation.

The slide consists of two flanged rivetted girders, inclined in position and situated exactly underneath the sides of the carriage proper; these are bound together transversely at either end and also in the middle by other flanged girders, the whole of the work being of the most solid description. To the sides and rear end are fixed wrought-iron brackets, which carry the boards on which stand the men who work the gun. The whole slide is connected by means of a stout link with the pivot about which the traversing takes place. This pivot works in a socket in a cast-iron block, which is made in one piece with the smaller or inner circular traversing rail, and is connected with this latter by means of vertical brackets and a horizontally lying bedplate. The outer rail is quite independent, and is simply bolted down to the floor of the battery. The traversing motion is given by a chain, the two ends of which are fastened to the floor at equal distances on either side of the central position of the gun; after passing round small guide rollers the chain goes over the drum of a windlass fastened to the rear end of the slide; by turning the handle of the windlass the requisite motion is obtained. In case the chain or any part of the windlass should break, the two hind wheels or rollers of the slide have numerous holes drilled at equal intervals in their rims; by inserting bars in any one of these holes, and pressing on them, the whole can be turned through any angle required.

The recoil is checked by an ordinary hydraulic brake lying between the longitudinal girders of the slide, and in case of accidents four buffers are fixed to each of the end transverse girders.

The projectiles are lifted to the breech of the gun by means of a crane fixed to the right-hand longitudinal girder. The gib of this crane consists of a single tapering bar of iron bent to the required shape, and having a pair of pulleys and set of tackle attached to its apex, and a small windlass fixed to its other end. The weights are as follows:—

	lbs.
Weight of the carriage - - - -	12,430
„ slide - - - -	33,770
Total - - -	46,200
Gun - - - -	79,200
	125,400

The 11-in. howitzer (see Pl. 221, figs. 1, 2, 3,) is also intended for coast defence, and is mounted accordingly. The carriage and frame differ, however, very materially from those just described. The principal cause of change is the enormous elevation (75 deg.) at which it is intended to fire this piece. The strain thus thrown on the slide would be too great to admit of this latter being carried on four wheels, and accordingly the whole of the under surface of the longitudinal girders is made to bear evenly on a bedding prepared in the floor of the battery, in order that the shock of recoil may be distributed over as large an area as possible. The top surface of the slide is consequently situated very low down, and in order that the axis of the trunnions may be at the required height above the ground the sides of the carriage proper have to be made very deep. The train of wheelwork for giving the elevation is precisely the same as with the 12-in. gun; instead, however, o

there being two circular racks fixed to the gun there is only one, and it is fixed right underneath the axis of the piece, to which it is fastened at both ends. It is, of course, described about the axis of the trunnions as centre. In order to traverse the gun, the slide has two eccentric rollers attached to its rear end, which can be brought to bear whenever it is necessary to move the piece through any horizontal angle. The slide is, of course, thus lifted off its bedding, to which it can be restored when the traversing is finished, by simply turning the rollers out of gear. The apparatus for traversing is a windlass and chain, similar to that described above. The crane, hydraulic brake, and apparatus for running in and out, are the same as in all other carriages for coast defence.

	lbs.
Weight of the whole carriage and frame - -	20,284
„ gun - - - - -	22,000
Total - - - -	42,284

The short 10·23-in. naval gun (see Pl. 221, figs. 4, 5, 6) is mounted on a naval battery carriage and slide, which differs from those usually in use in having a self-acting running-out arrangement and a new form of hydraulic brake, which will hold the gun still at any given position on the slide. This invention emanated from the Austrian Naval Department, and is as follows :—Instead of the liquid glycerine being forced through a perforated piston, as is usually the case, it is made to pass altogether out of one end of the cylinder through a pipe by which it returns to the other end. On its passage it has, however, to pass through a valve which is weighted or held down by a strong spring similar in construction only much smaller than an ordinary railway carriage spring. The valve can also be completely closed, so that no glycerine can pass, by simply pressing on a lever handle fixed to the left-hand side of the slide. This apparatus manifestly fulfils all that is required of it, for the recoil is overcome by the resistance offered to the passage of the liquid past the weighted valve, and the gun on running out can be held fast in any position on the slide by simply closing completely this same valve, for the piston (which is, of course, connected with the carriage) is in this case arrested in its forward motion by the column of liquid in front of it, which cannot escape except by bursting the cylinder.

The apparatus for giving the elevation consists of two circular racks and two trains of wheels, precisely similar to the arrangement adopted in the 12-in. gun. Both trains are, however, worked from only one side of the carriage.

The longitudinal girders of the slide for guns of this and smaller calibres are formed of rolled joists. The pivot about which the whole revolves is situated in the side of the ship just underneath the lower sill of the port, but for the sake of greater security the front end of the slide is connected by means of two stout iron hooks with a rail bent so as to be concentric with this pivot.

The traversing arrangement in this case differs from those previously mentioned. The hindermost of the two rails on which the slide revolves is cast in gun-metal, and is so formed that the back part constitutes the rail proper on which the rollers rest, while the front edge is bevelled and has teeth formed in it. With these teeth is engaged an ordinary toothed wheel, set on an axle inclined so as to be parallel to the bevelled edge, and taking its motion from a worm gear which is worked from the hinder end of the slide. This arrangement renders it unnecessary to have a separate brake in order to keep the slide steady in any particular position.

	lbs.
Total weight of carriage and slide - -	19,263
„ gun - - - -	39,600
Total - - -	58,863

The long 9·44 in. naval gun was mounted for fighting in the corner of a battery of a central battery ship (see figs. 1, 2, 3, Pl. 222). It is intended

for firing out of the last broadside port, and also, whenever required, out of the adjacent port right ahead or astern, as the case may be, consequently the slide must be arranged for rapid port changing. This is managed as follows :—The slide stands upon three traversing rails, the central and hindermost of which are bolted down to a turntable, while the foremost one is attached to the deck itself. In order to change ports the gun must first be run in, the slide disconnected with the pivot about which it turns, the rollers standing on the forward rail must be raised from contact with this latter by means of an hydraulic apparatus fitted for this purpose to the slide, and lastly, the turntable must be turned through a right angle, which operation brings the gun in a line with the port required ; the gun can then be run out, the slide connected with a second pivot, and the rollers lowered again into place upon a new traversing rail. In order to facilitate the disconnexion with the pivot, the link joining the latter with the slide is made in two pieces united by a bolt, by withdrawing which the connexion ceases.

The apparatus for elevating the gun (between + 10 deg. and − 5 deg.) is, on account of the light weight of the piece, comparatively simple ; it consists merely of a single pinion on each side of the carriage, working into circular racks precisely similar to those described above. The motion is given to a cast-iron disc which is on the same axis as the pinion, and has cylindrical sockets formed round its rim in order to receive short removable pins which serve as handles.

There is no self-acting running-out arrangement on this slide, but both running in and out are effected by means of two endless chains, viz., one on each side of the gun ; each chain passes over a pulley attached to the slide near its forward end and also over the drum of a windlass fixed to the rear end ; the upper portion of the chain passes through a box fastened to the side of the carriage. The chain may be either locked or unlocked in this box by turning a lever handle provided for the purpose. It is evident that if the handles of the windlasses be turned when the chain is locked, the carriage will move in the same direction as the upper portion of the chain. In order to keep the chain perfectly taut, and thus prevent the possibility of slipping, the forward pulley is provided with an adjustable bearing, which can be moved backwards and forwards at will by means of a screw. The recoil is governed by plate compressor brakes.

The apparatus for traversing is the same as that for the 10-in. gun. The worm wheel is driven by the same gear which works the chains for running the gun in and out. When not wanted for traversing, the two gears can be disengaged from each other.

	lbs.
Weight of the carriage - - - -	5,156
„ slide - - - -	12,125
	17,281
„ gun - - - -	34,100
	51,381

The long 8·268 in. gun, see Pl. 220, fig. 1, was mounted on a carriage and slide which is precisely the same in general form and design as the carriage and slide of 12-in. gun already described. The two differ from each other only in dimensions and small details of construction. For example, the top and bottom flanges of the longitudinal girders of the slide for the 12-in. piece are connected with the web by means of angle irons and rivetting, whereas in the present case these girders are rolled joists of I-shaped section.

The height of the axis of trunnions above the ground = 7 ft. $\frac{9}{16}$ in.

	lbs.
Weight of the carriage - - - -	4,598
„ slide - - - -	11,242
	15,840
„ gun - - - -	20,000
Total - - 16·89 tons =	35,840

The 8·268-in. siege gun was provided with an experimental carriage and slide, which was designed by Krupp to meet the wants of the modern Prussian siege artillery. The carriage proper has nothing remarkable about it. Its sides are formed as usual of solid doubled plates of wrought-iron. The apparatus for elevation is the same as that of the 24-centimetre gun. The slide is very short and light. Its forward end rests directly on a cast-iron block, which contains the pivot about which the whole revolves in a horizontal plane. The rear end stands on the two traversing rollers. Both the cast-iron pivot block and the traversing rail are fastened down to a bedding made of stout balks of oak frame together. There is no special machinery for traversing; the required motion is given by inserting short handspikes into sockets formed in the rims of the racers. The slide is provided with an hydraulic brake for regulating the recoil, the usual buffers, and a small crane for loading purposes, just like the carriages for coast defence. Its chief peculiarity lies in the way in which it is rendered transportable. Whenever it is necessary to move the gun from one point to another the slide can be mounted on wheels in the following manner:—The gun is first run in so that the carriage may be well out of the way, and not interfere with the position which the axle of the hinder pair of wheels is eventually to occupy. The wheels, with their axle of square forged iron, are then run over the front part of the slide, and are brought to a standstill when the axle comes in line with the bearings. The slide is then lifted by means of a pair of screwjacks, which are permanently attached to the longitudinal girders, until these girders come in contact with the under surface of the axle, which can then be made fast in its bearings. The other end of the slide has a trail piece attached to it, with an eye formed in the extreme end, by means of which the whole gun carriage and slide can be limbered up on to a limber, consisting simply of a pair of wheels, with the necessary framework for supporting the trail piece, the shaft or pole for the horses, &c. The eye in the trail piece passes over a pin in the limber, in the same manner as with an ordinary field-piece. The rollers or racers for traversing can be detached and carried separately. The whole affair, as thus mounted on wheels, can be transported by rail in a goods truck. The timber platform or bedding can be carried in an ordinary truck. Fig. 4, Pl. 222.

The larger pair of wheels are 6 ft. 7 in. in diameter. The tyres are formed of gun metal ⌊—⌋-shaped in section and $\frac{1}{10}$ in. wide. The spokes are simple rods of wrought iron. The small pair of wheels is of similar construction, the diameter is, however, 5 ft. 1 in. The load is divided between the axles of the large and small pair of wheels in the ratio of 4 to 1.

In order to put the gun in position for firing on its arrival in the battery, it is first brought on its wheels to its bedding; the traversing racers are then attached to the slide, which latter is then unlimbered so that the racers stand on the traversing rail, the front end is then detached from the axle of the large pair of wheels, and is lowered by means of the screwjacks on to the pivot block. The wheels are then rolled off, the gun run out, and everything is ready to commence firing.

	lbs.
Weight of the carriage proper - - - -	2,024
„ frame - - - -	3,801
	5,825
United weight of gun, carriage, slide, limber, and large pair of wheels - - - -	17,952
The platform or bedding weighs complete - -	4,576
Total - - - 10 tons =	22,528

Excessively ingenious as the whole arrangement undoubtedly is, it appears to be far too complicated and delicate in construction to undergo, without injury, the rough work of a siege. In this respect it contrasts badly with the simple carriages of the heavy English siege artillery. It is the design of a mechanic and not of an artilleryman.

The 6·692-in gun is intended to be fired from the bow or stern of an armoured ship. There is nothing peculiar either about carriage or slide. The recoil is controlled by a plate compressor. As a rule the slide lies directly on the traversing rails, but whenever it is requisite to train the gun through an horizontal angle, the hind rollers, which are eccentric, can be brought into play, the under surface of the slide is thereby removed from contact with the rails, and the whole can be easily turned through any angle required.

The height of the axis of trunnions above the deck is 3 ft. 4⅛ in.

	lbs.
Weight of the carriage - - - -	3,861
„ slide - - - -	4,917
	8,778
„ gun - - - -	12,320
Total -	8·09 tons = 21,098

The 5·9 in. siege gun has an ordinary siege carriage with wooden wheels and a wrought-iron trail. The elevation, which is given by a screw, ranges between + 35 deg. and—5 deg. Figs. 5, 6, Pl. 222.

The chief peculiarity of the carriage is the hydraulic brake, which limits the range of the recoil to between ¾ and 1 metre. The cylinder is movable in a vertical plane, and is attached to the trail at one-third of its length from the end. The piston rod is movable both in a horizontal and vertical plane, and is attached by means of a pivot bolt to an anchor made fast in the breastwork.

The height of the trunnion axis above the ground is 6 ft.

	lbs.
Weight of the carriage - - - -	4,059
„ gun - - - -	6,600
Total - - -	10,659

The other 5·9 in. gun (see Pl. 222, figs. 7, 8) is intended for use in the broadsides of corvettes. The carriage is provided with a slide. The elevation is given by a circular rack and pinion; the recoil is checked by a plate compressor, and the traversing effected by means of tackle applied to the rear end of the slide. As a rule the slide rests on the traversing rails; it can, however, when required, be mounted on traversing rails.

The axis of the trunnion is 37¾ in. above the deck.

	lbs.
Weight of carriage - - - -	3,311
„ slide - - - -	2,057
	5,368
„ gun - - - - -	8,800
Total -	14,168

The 4·724 in. gun has a naval carriage (see Pl. 222, figs. 9, 10, 11), and is intended for the smaller class of fighting ships. It consists of a wrought-iron frame, and was in fact the only carriage exhibited by Krupp, the sides of which are not solid plates. It is mounted on four rollers, the hinder pair of which are eccentric. The hydraulic brake is movable about pivots, both in a vertical and horizontal plane; the piston rod is attached to the carriage, and the vertical pivot of the cylinder is fastened down to the deck, and serves also as the centre about which the traversing takes place. In order to effect this latter operation, the hind rollers are put out of gear, the end of the carriage of course falls a little, and another roller (which has its bearings set transversely in a frame fixed athwart the sides of the carriage) comes into play on the traversing rail.

The elevation ranges between + .15 deg. and − 10 deg., and is given by

means of a circular rack and pinion. The height of the trunnion axis above the deck = 35 1/16 in.

	lbs.
The weight of the carriage - - -	1,969
" " gun - - - -	3,080
Total -	5,049

The Armstrong Collection.

The Armstrong Exhibition of Artillery at Vienna ranked next in extent if not in importance to the collection by Messrs. Krupp, of Essen. It was contained in a wooden pavilion in one of the open courts of the British section of the Industry Palace, exactly opposite to the Western Agricultural Hall, and with the guns there was very appropriately associated an exhibition of armour plates by the two firms, Sir John Brown and Co., and Charles Cammel and Co., of Sheffield. The three firms exhibiting in this pavilion were especially distinguished in the awards made by the jury, for each of them obtained the highest recognition, namely, the Grand Diploma of Honour. It would be impossible to conceive anything more totally opposite in principle and design than were the guns exhibited by these two firms, namely Armstrong and Krupp, the two greatest private manufacturers in the world—and for this reason it will be particularly interesting to compare the results obtained by each of them.

The Elswick collection comprised eleven pieces, namely:—

One 12-pounder Armstrong breech-loading field-piece.
One 9-pounder Armstrong breech-loading field-piece.
One 16-pounder muzzle-loading service field-piece.
One 9-pounder muzzle-loading service field piece.
One 6-pounder breech-loading Armstrong boat-gun.
One 68-pounder cast-iron gun, converted on Palliser system.
One 10-in. Fraser gun.
One 7-in. gun with polygrooved rifling, and improved French breech-loading arrangement.
One 23·5-centimetre Krupp gun, built up, however, on the English system, with steel barrel surrounded by wrought-iron coils.
Two Gatling mitrailleuses.

Taking the guns in the above order, we begin with the two breech-loading field-pieces, which were, till lately, the principal service weapons of the English field artillery. They were first introduced into the army in the year 1859, after a series of experiments, the results of which, as far as range and accuracy are concerned, may be summed up by stating that "the rifled "12-pounder gun could make better practice at a distance of two miles than "the 'old-fashioned 18-pounder service' smooth-bore could at one."

The following table gives the principal dimensions and details of rifling, &c., of these two field pieces, and of the 6-pounder boat gun:—

Nature, and Weight of Gun.	Calibre.	Length.						Diameter.		Rifling (Polygrooved).					Preponderance.
		Barrel Total.	Powder Chamber.	Shot Chamber.	Nominal.	From Muzzle to Axis of Trunnion.	From Axis of Trunnion to Breech.	Over Greatest Charge.	Muzzle.	Twist.	Grooves. Number.	Grooves. Depth.	Grooves. Width.	Width of Lands.	
	in.	in.	in.	in.	in.	in.	in.	in.	in.						cwt. qrs. lb.
12-pounder of 8 cwt.	3	61·875	8·5	3	72	38·75	33·25	9·75	5·75	1 turn in 38 calib.	38	·045	·148	·1	1 3 3
9-pounder of 6 cwt.	3	52·5	7·0	3	62	36·5	25·5	9·6	5·3	Ditto.	38	·045	·148	·1	0 2 26
6-pounder of 3 cwt.	2·5	53·0	7 0	2·5	60·12	37·0	23·125	7·0	3·75	1 turn in 30 calib.	32	·045	·148	·1	0 [illegible] 27

All three pieces are constructed on the original well-known coil system, invented by Sir William Armstrong. The 12-pounder and 6-pounder each consists of an inner barrel or tube, a forged breech-piece, a forged trunnion ring, and three strengthening coils. The 6-pounder has only one coil. The inner tubes of all these guns were originally made of coils welded together. Owing, however, to the difficulty of obtaining perfect welds, this construction was abandoned, and solid forged barrels, afterwards bored out, were substituted for them. Even these did not answer, for the fibre ran lengthwise, and was rapidly eaten out by the action of the powder gases. Steel was likewise tried, so that in the year 1872, out of 701 12-pounders, then in the service, 294 had coiled barrels, 286 were solid forged, and 121 were of steel.

The breech-loading apparatus consists of a vent-piece or breech stopper, which is inserted behind the chamber through a vertical slot in the rear of the gun, and is jammed home from behind by a hollow breech screw, the axis of which is coincident with the axis of the gun. The charge is put in through the hollow or cylindrical portion of the screw after the vent-piece has been removed. The screw is turned by means of a lever, which is free to revolve round the screw, the power being communicated by means of two tappets on the lever, which come in contact with two corresponding projections on a ring called the tappet ring, which is made fast to the end of the screw. Figs. 4, 5, 6, 7, Pl. 229, show the construction of the 6 cwt. 9-pounder breech-loader.

The vent-piece, which is the tender part of the gun, is so called because the vent passes through it. Owing to the action of the powder gases, the channel gets worn often to ten times its right size, thus seriously injuring the strength of the piece. Many accidents have happened in consequence. Each vent-piece consists of the following parts: The body, the vent bush copper in two parts, the vent-piece copper ring, the crosshead, the shackles. The weights for the 12, 9, and 6-pounders are respectively 15 lb., 14¾ lb., and 8¼ lb., and the material used in their contruction is at present Marshall's refined iron, but wrought iron, steel, Swedish iron, and steel toughened in oil, have been tried in succession without any good results. The vent channel is in two portions, viz., a vertical and a horizontal part. The upper end of the former part is bushed with copper where the friction tube rests; the horizontal portion has no bush, for its presence would dangerously weaken the body of the vent-piece. The vent-piece copper ring is let into that portion which bears against the rear end of the barrel of the gun. The barrel has a corresponding ring let into it. The two are coned in opposite ways, so as to fit into each other, their principal object being to prevent any escape of gas.

Several special committees of artillery officers have since 1863 reported against the system of breech-loading field artillery described above, but it was not till the year 1870, on the report of Major-General St. George's Committee, that it was finally decided to replace the existing weapons by wrought-iron muzzle-loaders with steel tubes, bronze muzzle-loaders having been previously tried and failed.

The reasons given in favour of the muzzle-loaders were that they are simpler, easier to repair and work, can be fired more rapidly, and cost less both to manufacture and maintain than the breech-loaders. As regards projectiles and ammunition, it is possible to employ shrapnel shell with ordinary wooden time fuses in the muzzle-loader; whereas with the breech-loader, on account of the absence of windage, it was necessary to light the fuse by means of a detonator, which easily got out of order, and could not therefore be depended upon. Moreover, the "cartridges of the breech-loading guns " have the great disadvantage of requiring the use of lubricators." As far as regards practice, it was stated in the report that "the 9-pounder muzzle-" loader and the 12-pounder breech-loader guns appear in respect to shooting to " be much upon a par, the former being superior in point of shrapnel shell with " time fuses; the latter in point of segment shell with percussion fuses, the " 9-pounder breech-loading gun being inferior to both."

In consequence of this report it was decided to arm all the Horse Artillery and half the field batteries at home with the 9-pounder muzzle-loading gun of 8 cwt., and the remaining field batteries at home with the 16-pounder muzzle-loading gun of 12 cwt. In consequence of the 9-pounder bronze guns for India having failed it was determined to supply the Indian army also

with the compound steel and wrought-iron piece. As a specimen of each of these guns was exhibited by the Elswick Ordnance Co., we shall now proceed to describe them.

The 16-pounder muzzle-loading gun of 12 cwt. (figs. 3, 4, 5, Pl. 223) was introduced into the service on account of the inefficiency of the common shell of the then existing 12-pounders and 9-pounders, the special committee on shrapnel *v.* segment shell in 1869 recommending "the introduction of a field howitzer which " should be a muzzle-loader suitable for high angle firing, and capable of throw- " ing a common shell with a bursting charge, like the howitzers in smooth- " bored batteries." In 1870 a special committee " recommended the adoption " of a rifled gun of about 12 cwt., having a calibre between 3·5 in. and 3·7 in." The weapon as eventually adopted has a calibre of 3·6 in. It is made up of two parts, viz., a steel tube toughened in oil, and a jacket of wrought iron, consisting of a single breech coil, a trunnion ring, and a second coil in front of the trunnions, all three being welded together. The chase consists solely of the steel tube without any reinforcing whatever, and on account of this the tube is stronger in the chase than anywhere else. It is, in fact, turned down in two successive steps, so that the weakest part is over the chamber, a circumstance which gives the tube a very ugly appearance, suggesting weakness at the shoulders of the steps. It must, however, be stated in common fairness, that the gun has shown itself amply strong in practice. The cascabel is turned out of the solid end of the tube. It is vented with a hardened copper vent right at the end of the powder chamber, so as to admit of firing with varying sized charges, and also to insure the whole of the charge being blown out, a point of very great importance with muzzle-loaders. The rifling consists of three grooves on what is known as the modified French system, the twist, which is uniform, having one turn in 30 calibres.

The service charge is 3 lb. of L. G powder, and the initial velocity is 1,355 ft.

The 9-pounder, of 8 cwt., is precisely similar to this gun in construction, with the sole exception that it has a small swell at the muzzle turned out of the steel tube. (Figs. 8, 9, 10, 11, 12, 13, Pl. 229, and figs. 27, 28, 29, Pl. 223.)

The following tables give all the details of dimensions, ammunition, and range of both these pieces:—

Nature, and Weight of Gun.	Length.			Rifling.		Grooves.			Preponderance.
	Gun.	Bore.	Rifling.	System.	Spiral.	No.	Depth.	Width.	
	ft. in.	in.					in.	in.	lb.
16-pounder gun of 12 cwt.	6 2·45	68·	58·04	Modified French.	Uniform one turn in thirty calibres.	3	·11	·8	10
9-pounder gun of 8 cwt. 3 in.	5 8·5	63·5	59·8			3	·11	·8	7

AMMUNITION. See figs. 9 to 16, Pl. 223.

Shells.		Case Shot.	Charge for Gun.	Initial Velocity.
Common.	Shrapnel.			
		lb. oz.	lb.	ft.
Weight equals 15 lb. 13 oz., including 1 lb. 0¾ oz. bursting charge.	Weight equals 16 lb. 5 oz., including 1¾ oz. bursting charge.	15 3	3 L.G.P.	1,355
Weight equals 9 lb., including 8 oz. bursting charge.	Weight equals 9 lb. 4 oz., including 12 drs. bursting charge.	9 12	1¾ „	1,381

There are two kinds of fuses in use, viz., 1, a percussion screw field-service muzzle-loading fuse, for use with both kinds of shell when intended to burst on graze; and 2, the Boxer wooden time fuse, of which latter description there are two sorts, one being for use with shrapnel shell when the time of

flight is less than 5 seconds, and the other for use with both kinds of shell when the time of flight is under 9 seconds. (Figs. 6, 7, 8, 23, 24, Pl. 223.)

The following is the official range table, with common shell or shrapnel and service charges:—

Sixteen-Pounder.				Nine-Pounder.			
Distance of Object.	Elevation.		Time of Flight.	Distance of Object.	Elevation.		Time of Flight.
yards.	deg.	min.	seconds.	yards.	deg.	min.	seconds.
100	0	0	0·25	100	0	0	0·25
200	0	0	0·50	200	0	6	0·50
300	0	7	0·76	300	0	14	0·80
400	0	19	1·03	400	0	26	1·05
500	0	31	1·30	500	0	39	1·35
600	0	44	1·58	600	0	52	1·70
700	0	57	1·86	700	1	5	1·95
800	1	10	2·15	800	1	18	2·25
900	1	24	2·44	900	1	31	2·55
1,000	1	38	2·73	1,000	1	44	2·85
1,100	1	52	3·02	1,100	1	57	3·20
1,200	2	6	3·32	1,200	2	12	3·55
1,300	2	21	3·63	1,300	2	28	3·85
1,400	2	36	3·94	1,400	2	45	4·15
1,500	2	51	4·26	1,500	3	2	4·45
1,600	3	7	4·58	1,600	3	20	4·75
1,700	3	23	4·90	1,700	3	38	5·10
1,800	3	40	5·23	1,800	3	38	5·45
1,900	3	57	5·56	1,900	4	18	5·80
2,000	4	15	5·90	2,000	4	40	6·15
2,100	4	33	6·25	2,100	5	2	6·50
2,200	4	51	6·60	2,200	5	24	6·90
2,300	5	10	6·96	2,300	5	47	7·30
2,400	5	30	7·32	2,400	6	10	7·70
2,500	5	50	7·69	2,500	6	34	8·10
2,600	6	10	8·06	2,600	6	59	8·50
2,700	6	30	8·44	2,700	7	25	8·90
2,800	6	51	8·82	2,800	7	52	9·30
2,900	7	12	9·21	2,900	8	20	9·80
3,000	7	33	9·60	3,000	8	48	10·30
3,100	7	55	10·00	3,100	9	18	10·80
3,200	8	17	10·41	3,200	9	49	11·40
3,300	8	39	10·83	3,300	10	21	12·00
3,400	9	1	11·26	3,400	10	53	12·70
3,500	9	23	11·70	3,500	11	27	13·45
3,600	9	46	12·14				
3,700	10	9	12·59				
3,800	10	33	13·04				
3,900	10	57	13·50				
4,000	11	22	13·96				

In a series of experiments carried on at Bourges by order of the French Government, better ranges than those given above were got out of the service 9-pounder under the same conditions of charge and projectiles, as the following table shows:—

Angle of Elevation.	deg. 6	deg. 8	deg. 10	deg. 12	deg. 14	deg. 16	deg. 18	deg. 20	deg. 22
Range, yds.	2,501	3,013	3,468	3,869	4,236	4,565	4,867	5,141	5,389

Before quitting the subject of these field-pieces, it must be noticed that they constitute the only striking success as yet attained in the Royal Arsenal. Both in simplicity, durability, accuracy of shooting, and flatness of trajectory they leave little to be desired. They form at present the standard which Continental nations are trying to come up to, and if possible to surpass. The French Commission appointed to carry on the experiments at Bourges referred to above, have after a series of exhaustive trials with guns of all descriptions, come to the conclusion, "that the Woolwich "service gun gives results which are not inferior to those of any other field "gun actually in the service in Europe."

The next gun on the list is the Palliser 64-pounder, which is, as is well known, the old smooth-bore cast-iron 8-in. gun, of 65 cwt., converted into a rifled gun by the insertion of a wrought-iron tube or barrel, which gives the weapon strength enough to bear rifling. (Fig. 2, Pl. 223.)

The operation of conversion is as follows:—The original cast-iron gun is first bored out to 10·5 in. diameter. The muzzle has then a screwed recess let into it, in order to receive a collar, the use of which is to prevent the barrel from shifting its position. Lastly, a gas channel is bored from the cascabel to the base of the bore, the nature of which will be presently explained. The barrel is formed on the original Armstrong system of five wrought-iron coils united together, the end being closed by a wrought-iron cup which is screwed into the end of the tube. The whole is then tested with water pressure of 120 lb. on the square inch in order to see if there be any leaks or not. The breech end of the barrel is next turned down for a length of 32 in. to rather less than half its original thickness, and a spiral groove is cut on the outside, which communicates at the rear end with the gas channel mentioned above. The original strength of the barrel at this time is now restored by shrinking on a reinforcing tube formed of two wrought-iron coils joined together, the object of all this complication being to allow the gas to escape along the spiral groove and gas channel in the event of the inner tube bursting, and thus to save the whole gun from disruption. It seems to us, however, that the gun is much more likely to burst from the want of continuity of the tube at this point, than it would be if the barrel were maintained throughout at its original thickness; for the theoretical value, even of a tube shrunk on with initial tension, is but small when the thickness of the barrel is small compared to its calibre, and this advantage is still further diminished, if not altogether nullified, by the well-known practical impossibility of regulating the amount of the initial tension to the nicety required in theory. Moreover, in this description of gun the whole state of tension in the barrel is completely changed after the two proof rounds, which are supposed to expand the inner barrel (which has previously been given a play of from 0·007 in. to 0·015 in.), so as to fit tightly into the cast-iron jacket. On the other hand, the evils of a want of continuity are well known and fully recognised.

To revert to the process of manufacture. The tube is finished by being fine-turned with the amount of play stated above, after which it is fitted into the cast-iron part, the chief difficulty now being to make the flat end of the tube bear quite evenly against the base of the bore in the cast-iron part. Great care, however, is taken in rounding off the shoulder of the tube, so that it shall not come into contact at all with the cast-iron, for it is considered that if the two touched each other the tube, on expanding, would tend to split open the jacket by acting as a wedge. When the tube is fixed the collar is screwed into the muzzle, and the barrel is further prevented from turning round by inserting a wrought-iron pin into the body of the gun, and the tube underneath the chase. These guns are now all rifled with three plain grooves, the shunt system having very wisely been definitely abandoned. It was originally intended to fire these and the other converted guns with battering charges, but that idea has now been given up, and the charge is limited to 8 lb. R. L. G. powder, the projectile being a common shell weighing 64 lb. 9 oz., of which 7 lb. is the bursting charge. In addition to the common shell, shrapnel, and also case shot are used against boats and bodies of troops. The initial velocity is 1,245 ft. per second.

The following tables correspond with those previously given for the field guns :—

Nature, Weight, and Service.	Length.			Rifling.		Grooves.			Preponderance.
	Gun.	Bore.	Rifling.	System.	Spiral.	No.	Depth.	Width.	
	ft.	in.	in.				in.	in.	cwt.
64-pounder gun of 71 cwt., 6·3 in. calibre for land and sea service.	9·0	103·27	96·27	Plain Groove.	Uniform one turn in forty calibres.	8	·115	·6	6,375

AMMUNITION.

Shells.		Case Shot.	Charge for Gun.	Initial Velocity.
Common.	Shrapnel.			
Weight equals 64 lb. 9 oz., including 7 lb. bursting charge.	Weight equals 65 lb., including 9 oz. burst-charge.	lb. 51	lb. 8 R.L.G. powder.	1,245

OFFICIAL RANGE TABLE.

Distance of Object.	Elevation.		Distance of Object.	Elevation.	
yards.	deg.	min.	yards.	deg.	min.
100	0	10	1,900	4	14
200	0	21	2,000	4	31
300	0	32	2,100	4	48
400	0	43	2,200	5	6
500	0	55	2,300	5	25
600	1	7	2,400	5	44
700	1	19	2,500	6	4
800	1	32	2,600	6	24
900	1	45	2,700	6	45
1,000	1	58	2,800	7	6
1,100	2	12	2,900	7	28
1,200	2	26	3,000	7	50
1,300	2	40	3,100	8	13
1,400	2	55	3,200	8	36
1,500	3	10	3,300	9	0
1,600	3	25	3,400	9	24
1,700	3	41	3,500	9	49
1,800	3	57	3,600	10	14

The 10-in. gun (fig. 1, Pl. 223) is a good example of the Fraser system of construction, which, in the year 1867, superseded the then existing or Armstrong method. The difference between the two systems is considerable, for with Armstrong the inner barrel is surrounded by a considerable number of coils, which have all to be fine-turned, bored, and shrunk on one another. In the Fraser system, on the other hand, the steel tube is strengthened generally by one solid jacket over the rear end of the gun, which includes the trunnion ring, and one tube over the chase, a modification which introduces great

economy into the manufacture, for all the fine work involved in boring, turning, and shrinking is replaced by the comparatively simple operation of forging triple coils. Moreover, the solidity and homogeneity of the structure thus produced more than outbalances the theoretical advantage of a better distribution of the tension given by the many-coiled system, for it has been found that this theoretical advantage is lost by the impossibility of attaining to absolutely accurate workmanship. Whatever be the faults of the English system of heavy ordnance, there can be no doubt that the Fraser method of internal construction gives results as to strength and endurance which have never been exceeded, except by Sir Joseph Whitworth, and that, too, at a cost of, in round numbers, 33 per cent. below the original Armstrong and the modern Krupp systems.

The 10-in. gun in question consists of a solid-ended tube of toughened steel, which is thinner at the muzzle than at the chamber; the chase is strengthened by a single coil called the B tube, while the whole of the rest of the gun consists of a single jacket, formed of a triple coil, a trunnion ring, and a second triple coil in front of the trunnions, all three being welded together, and the trunnion ring being so arranged as to encircle the joint between the two coils. The front end of this jacket is recessed, so as to enable it to overlap the B tube for several inches, and thus the continuity of the structure is preserved at all the joints. The breech is closed by a screw cascabel, which bears evenly against the solid end of the inner barrel. A gas-escape channel is cut along the thread of this piece, so that in the event of the barrel splitting the danger may be recognised at once before further damage is done.

The rifling is on the so-called Woolwich system, with seven grooves, having a twist increasing from 1 in 100 to 1 in 40. The forward ends of the grooves are widened out, so as to admit of the studded projectile being inserted with ease. This gun was introduced into the service in 1868, in order to arm H.M.S. "Hercules," the existing 9-in. guns not being considered powerful enough. The 10-in. is, indeed, a great improvement over these latter pieces, for at a range of 2,000 yards it can strike nearly as hard a blow as the 9-in. can at the muzzle.

The following tables give all the details as before :—

Nature and Weight of Gun.	Length.			Rifling.		Grooves.			Preponderance.
	Gun.	Bore.	Rifling.	System.	Spiral.	No.	Depth.	Width.	
	ft. in.	in.	in.						
10-in. gun of 18 tons.	14 2	145·5	118	Woolwich	Increasing from 1 in 100 to 1 in 40	7	·2	1·5	Not to exceed 3 cwt.

Ammunition.

Charge.		Shot.		Shells.			Initial Velocity.	Total Energy.
Battering.	Service.	Palliser.	Case.	Common.	Palliser of large capacity.	Shrapnel.		
		lb.	lb.					
70 lb. pebble. 60 lb. R.L.G.	44 lb. pebble. 40 lb. R.L.G.	400	130	400 lb. including 26 lb. 4 oz. as bursting charge.	400 lb. including 6 lb. 14 oz. as bursting charge.	383 lb. including 1 lb. as bursting charge.	1,298 ft. with 60 lb. charge R.L.G. 1,364 ft. with 70 lb. charge of pebble powder.	5,160 ft. tons at muzzle with 70 lb. charge of pebble and 400 lb. projectile.

OFFICIAL RANGE TABLE.

Distance of Object.	Charge=40 lb. R.L.G., or 44 lb. P. Projectile: Common Shell.		Charge=60 lb. R.L.G. Projectile: Palliser.		Charge=70 lb. P. Projectile: Palliser.		Charge=70 lb. P. Projectile: Common Shell.	
	Elevation.	Time of Flight.	Elevation.	Time of Flight.	Elevation.	Time of Flight.	Elevation.	Time of Flight.
yards.	deg. min.	secs.	deg. min.	secs.	deg. min.	secs.	deg. min.	secs.
100	0 13	0·26	0 9	0·20	0 6	—	0 9	0·25
200	0 24	0·54	0 18	0·43	0 13	—	0 18	0·50
300	0 36	0·82	0 28	0·67	0 22	—	0 27	0·75
400	0 48	1·10	0 38	0·91	0 31	—	0 36	1·00
500	1 1	1·38	0 48	1·15	0 40	—	0 46	1·25
600	1 14	1·67	0 58	1·40	0 49	—	0 56	1·50
700	1 27	1·86	1 8	1·65	0 58	—	1 6	1·75
800	1 41	2·25	1 18	1·91	1 7	—	1 16	2·0
900	1 55	2·54	1 29	2·17	1 16	—	1 26	2·25
1,000	2 9	2·83	1 40	2·43	1 26	—	1 37	2·51
1,100	2 23	3·12	1 51	2·69	1 36	—	1 48	2·77
1,200	2 37	3·42	2 2	2·96	1 47	—	1 59	3·03
1,300	2 51	3·73	2 13	3·23	1 58	—	2 10	3·29
1,400	3 6	4·04	2 25	3·50	2 9	—	2 21	3·55
1,500	3 21	4·35	2 37	3·77	2 21	—	2 32	3·81
1,600	3 36	4·66	2 49	4·05	2 33	—	2 44	4·07
1,700	3 51	4·97	3 1	4·33	2 45	—	2 56	4·33
1,800	4 7	5·28	3 13	4·61	2 57	—	3 8	4·60
1,900	4 23	5·60	3 25	4·90	3 9	—	3 20	4·87
2,000	4 39	5·92	3 38	5·19	3 22	—	3 32	5·15
2,100	4 56	6·24	—	—	3 35	—	3 44	5·43
2,200	5 13	6·56	—	—	3 48	—	3 56	5·71
2,300	5 30	6·89	—	—	4 1	—	4 9	5·99
2,400	5 47	7·22	—	—	4 14	—	4 22	6·27
2,500	6 5	7·56	—	—	4 27	—	4 35	6·55
2,600	6 23	7·90	—	—	4 40	—	4 48	6·85
2,700	6 42	8·24	—	—	4 54	—	5 1	7·15
2,800	7 1	8·58	—	—	5 8	—	5 15	7·45
2,900	7 21	8·93	—	—	5 22	—	5 29	7·75
3,000	7 41	9·29	—	—	5 36	—	5 43	8·05
3,100	8 1	9·65	—	—	5 50	—	5 57	8·35
3,200	8 21	10·02	—	—	6 4	—	6 12	8·66
3,300	8 42	10·39	—	—	6 18	—	6 27	8·98
3,400	9 3	10·76	—	—	6 32	—	6 42	9·30
3,500	9 25	11·14	—	—	6 46	—	6 57	9·62
3,600	9 47	11·52	—	—	7 0	—	7 12	9·94
3,700	10 9	11·90	—	—	7 14	—	7 28	10·27
3,800	10 32	12·29	—	—	7 28	—	7 44	10·60
3,900	10 56	12·68	—	—	7 42	—	8 0	10·94
4,000	11 21	13·08	—	—	7 56	—	8 16	11·29
4,100	—	—	—	—	8 10	—	8 32	11·64
4,200	—	—	—	—	8 24	—	8 48	11·99
4,300	—	—	—	—	8 38	—	9 5	12·35
4,400	—	—	—	—	8 52	—	9 22	12·71
4,500	—	—	—	—	9 6	—	9 39	13·07
4,600	—	—	—	—	9 20	—	9 57	13·44
4,700	—	—	—	—	9 34	—	10 15	13·81

In addition to the Elswick collection of artillery, there was exhibited at Vienna, in the British section, a 7-in. gun by Mr. Vavasseur, of the London Ordnance Works, Southwark, which is deserving of special notice on account of many peculiarities in the design, not only of the weapon itself, but also of its carriage and slide.

The gun is built up entirely of Firth's cast steel, with the exception of the trunnion ring, which is of wrought iron. It consists of a continuous inner barrel tempered in oil, and turned down thin, with a sharp shoulder for the last 16 in. at the muzzle end. This tube is enveloped from end to end by a tubular jacket, in two parts, one of which extends continuously from the rear to 2 in. forward of the trunnion ring, while the other part covers the chase.

The first-mentioned part projects 8 in. behind the base of the barrel, and contains the female screw for the cascable. The remainder of the gun, with the exception of the trunnion band, is built up of steel rings, forged and rolled like railway tyres, so that the fibre runs circumferentially. These rings are arranged in two sets of steps, one of which terminates at 27 in., and the other at 48 in., from the muzzle. They are, moreover, so arranged that the part behind the trunnions consists of one tier of thick rings, while the forward end has two thin tiers as far as the first step or shoulder, and one thin tier as far as the second step. The rifling consists of three projecting ribs, instead of the usual grooves. Each rib is 1 in. wide, and 0·2 in. high, and the twist, which is regular, is one turn in 35 calibres. The projectile is, of course, grooved to correspond, the windage being 0·08 in. over the body, and 0·05 in. in the grooves. The construction is clearly shown in Pl. 224.

The advantages claimed for this system of rifling are :—.

1. That it provides perfectly for the centering of the projectile.

2. That it strengthens, rather than weakens, the inner barrel of the gun; for example, the area of the bore of a 12-in. gun rifled on the Woolwich system, with nine grooves, is 115·36 square inches, whereas, rifled with three ribs, the area is 111·70 square inches, a difference in favour of the latter system of 3·66 square inches.

3. The projectile is not weakened so much by the three shallow grooves as it is by the comparatively deep countersinks for the studs, consequently the walls may be made thinner, and a larger bursting charge be used with safety.

4. The bearing surface for turning the projectile is greatly in favour of the rib system; in fact, with studs there is no bearing surface at all, but only a few points.

It is, moreover, claimed that there is far less erosion in these guns than in grooved barrels, for in the latter system the powder gases rush along through the grooves in front of the base of the shot, and, being confined in comparatively narrow channels, have a much more injurious effect than they would have were they to act evenly over the whole circumference of the bore. The following tables give full particulars of the gun and its performances:—

Nature of Gun.	Length.			Diameter.			Nature and Twist of Rifling.	Weight of Cast-iron Shell.	Weight of Charges.		Initial Velocities.	
	Total.	Bore.	Ribs.	Of Bore at Bottom of Ribs.	Over Breech.	Over Muzzle.			Battering.	Service.	With Battering Charge.	With Service Charge.
	in.	in.	in.	in.	in.	in.		lb.	lb.	lb.	ft.	ft.
7-in. muzzle-loading gun of 101 cwt.	128·5	111·0	96·0	7·0	24·4	12·0	Uniform 1 turn in 35 calibres.	115·0	22·0	14·0	1412	1218

The R. L. G. powder was used when these velocities were taken; but Mr. Vavasseur is of opinion that with pebble powder the velocity would be increased to 1,540 ft. per second without any additional strain being thrown on the gun.

The gun has now fired in all 225 rounds, and is to all appearance as good as new.

The annexed table gives the ranges as obtained at Shoeburyness in a series of trials which took place in 1869–70.

Number of Rounds Fired.	Weight of Projectile.	Charge of Powder, R.L.G.	Elevation.		Time of Flight.	Mean Range.
	lb.	lb.	deg.	min.		yards.
3	115	22	1	19	Not taken	905
5	„	„	2	11	4·11 sec.	1,502
5	„	„	4	7	6·56 „	2,362
5	„	„	6	5	8·46 „	3,125
3	„	„	7	5	Not taken	3,487
5	„	„	8	4	10·9 sec.	3,839
1	„	„	19	32	24·3 „	7,450

Leaving the gun, and turning next to the carriage and slide, it will be observed that these latter differ in most important respects from all other similar objects shown at the Exhibition. This difference does not lie so much in the framework of either, which is formed as usual of wrought-iron plates at ⊓ irons rivetted together, but in the mechanism, whereby the recoil is checked, the gun run out, traversed, and elevated.

The recoil is checked by means of a screw which lies in a wrought-iron trough lying between the main frames of the slide and is grasped by a long nut in contact with the carriage in such a manner that as this latter moves backwards under the force of the recoil, the nut moves with it along the screw, thus causing it to revolve. To the front end of the screw is fixed a metal disc with a bevelled edge, which revolves freely inside a ring of the same thickness as the disc. The edge of this ring is a plain cylinder, but the inner edge is bevelled so as to fit closely against the corresponding edge of the disc.

Under ordinary circumstances the disc and ring are not in close contact, but when the recoil commences the first small motion of the nut jams the screw hard up against its bearings, that is to say, it brings the bevelled edges of the disc and ring into close contact, so that these two, together with the screw, revolve as if all were one piece. So far, however, we have no retarding motion; this latter is given by surrounding the outter rim of the ring with a band or strap brake similar to the kind used with cranes. This band can be tightened more or less by means of a screw provided with a pointer and index, which latter shows the degree of tightness necessary for different charges of powder. When once fixed, this does not require to be altered so long as the charge remains the same.

The screw is formed of a square bar of steel twisted so as to have a pitch of one turn in 30 in. It is carried in bearings fixed in the two ends of the trough, which latter is pivoted at its front end on trunnions, while the rear end merely rests on the cross frame of the slide. The trough is thus capable of motion in one plane, and consequently if the slide deflects on firing, the trough and the screw do not deflect or bend with it. Keeping the same end in view, the nut which causes the screw to revolve is not fastened directly to the carriage, but a casting on this latter is made to bear against a pair of small rollers on the nut, so that if the carriage jumps on firing, the nut and screw do not jump with it, and the casting on the carriage in its upward motion simply causes the rollers to revolve. The nut is guided in its motion by means of the top angle irons of the trough between, and on which it slides.

The running-out gear consists of a pair of spur wheels, viz., one on either side of the carriage, the teeth of which work into oval holes formed in a pair of angle irons rivetted to the inner sides of the main frames of the slide. These wheels are driven, as usual, by a train of wheelwork, the pinions of which next in position to the spur wheels are mounted on eccentric axes. The hind rollers of the carriage are also mounted on eccentric axes, in order

that when recoiling the whole may slide instead of rolling back. But in order to run out, the ecentric rollers are turned into position by means of a handspike, so that the carriage now stands on its four wheels instead of its flat base, and at the same time, and by the same motion, the eccentric pinions are brought into gear with the spur wheels, so that the gun and carriage can be moved forward by turning a winch.

In order to control the motion when running out in a seaway, a small strap brake is applied to a disc on the rear end of the compressor screw, which can be worked by hand, and by means of which the carriage can be instantly stopped in its forward motion. This is a very handy apparatus, not possessed by any hydraulic brake, with the exception of the one lately devised by the Austrians, and exhibited by Krupp and very superior to the corresponding part of the Ericsson plate compressor.

The elevation is effected by means of straight steel racks, instead of the circular ones generally in use. Their heads are attached to the gun in such a manner as to allow for the circular motion of this latter; they are moreover provided with a clamping apparatus in order to keep the gun fixed at any required degree of elevation.

The slide is provided with four rollers, the two forward ones being fixed while the others are mounted on eccentric pins, and are only brought into play whenever it is necessary to train the gun.

This carriage and slide has been tried by order of the French Government with the most satisfactory results, the compressor in particular having distinguished itself for the great certainty and uniformity of its action. The following are the principal data and dimensions:—

	Ft. in.
Carriage.	
Length	4 1
Breadth	3 1½
Height	2 8
Slide.	
Length	12 0
Breadth	3 2½
Height above deck fore end	1 2
„ „ rear end	1 5
Incline to rear	1½ deg.
	Cwt.
Weight of carriage	22
„ slide	32
„ gun	101
Total weight	155
Maximum recoil allowed for carriage	5 ft. 3 in.
„ angle of elevation	12½ deg.
„ „ depression	6 deg.

It is greatly to be regretted that Mr. Vavasseur did not exhibit his 12-pounder field gun, which has lately been experimented on at Bourges by order of the French Government with signally favourable results.

His copper-ringed projectiles, modifications of which are now adopted for the French heavy naval guns, and which are also being experimented on at Essen, would likewise have been interesting contributions.

The Swedish Guns.

The collection of heavy ordnance, and of field guns, contributed by Sweden to the Vienna Exhibition, was a small one, but of considerable interest, illustrating as it did the systems adopted by the Government, and the materials employed. The cast iron used in the manufacture of ordnance has long enjoyed a high reputation, and during the past ten years careful and continued investigations have been made in Sweden, with the view of improving the material, and so to produce guns which shall be reliable under the ever-increasing tests to which they are subjected. Probably in strength and durability the Swedish cast iron is superior to that employed in the United States of

America for heavy guns, while the prices at which it can be delivered are comparatively low.

Certainly the manufacture of guns and projectiles of cast iron has been attended in Sweden with satisfactory results, comparatively speaking, and such guns of all calibres, as well as armour-piercing projectiles, are introduced into the Swedish service.

The iron employed is obtained by a mixture of three classes of magnetic ores, those of Förola, Nartorp, and Stenebo. That of Förola has been known in Sweden during the past three centuries as the best for artillery purposes, and it forms 80 per cent. of the mixture employed, 10 per cent. of each of the two other classes being used. The ores are reduced in furnaces with charcoal and coal blast, and the pigs are carefully tested, selected, and classified according to their degrees of hardness. They are afterwards remelted in a reverberatory furnace, for guns as well as for projectiles.

The cast-iron is now only made at Finspong, and at Ankarsrum, and the process of production is similar at each place. Finspong makes and delivers material both for guns and projectiles, while at Ankarsrum only the metal for projectiles is produced.

At both works the metal is divided into ten classes, according to its hardness, which is shown by the fracture of a cylindrical bar taken as a sample, and having a length of 2 ft. with a diameter of $3\frac{1}{5}$ in. Each charge from the blast or reverberatory furnace is thus tested. The bar, when broken, will show, for the first class, a fracture quite black, and strongly graphitic, and for the tenth quality a pure white fracture, with no sign of graphite; the intermediate classes range between these limits.

Generally speaking the third, fourth or fifth classes are employed for guns and projectiles, sometimes the second class, but never any below the sixth.

The following analysis, taken from the test records at Finspong, shows the chemical composition of the cast iron when it has been re-cast in the reverberatory furnace:—

Silicia	0·48
Graphite	2·05
Carbon	1·41
Manganese	0·25
Sulphur	0·13
Phosphorous	trace
Aluminum	—
Calcium	—
Copper	trace
Metallic iron	95·68
	100·00

The special characteristics of the metal are, great strength, hardness, tenacity, and elasticity. A very remarkable specimen exhibited was a thin section, cut from a large gun at right angles to its axis, and which resisted extraordinary tests. The almost innumerable experiments that have been made show, too, a very uniform quality of material.

At Finspong, all guns of 5·2 in. calibre (24-pounders), and above, are cast with a hollow core, and after being cast the metal is cooled by a constant circulation of air in the core, while when it is withdrawn, the gun is further cooled with water. Pieces below 5·2 in. bore are cast in the ordinary way.

The testing of each gun is very carefully conducted, and is always carried out on a system based upon extensive experience. With each heavy piece cast, a small one (4 or 6 pounder) is made from the same metal, and this is submitted to extreme tests.

The larger rifled guns from 4·1 in. diameter upwards, are reinforced by one or two tiers of steel rings, which until the present have been manufactured at the French works of Rive de Gier and St. Chaumont, and to a small extent by the Seraing establishment of Belgium. For the most part the French system of breech closing is adopted, the parts of the breech being supplied by

the Swedish works of Bergsund and of Motala. From this latter place it is now intended to obtain the steel reinforce rings.

The ogival projectiles are, as already stated, cast at Finspong and Ankarsrum, the body in the sand, the head in iron moulds to obtain the chilled surface.

The following data, bearing upon the question of the Swedish artillery, will be found of interest. They bear directly on the powers of resistance exerted by the cast-iron employed in the fabrication of the large guns.

A rifled cannon, 11 in. bore, made in 1866 for the Danish Government, fired 245 rounds, for the most part with a charge of 59 lb. of powder and a 485 lb. shot. At the end of this test the gun remained in good condition. It was afterwards destroyed by the explosion of a shell filled with dynamite in the bore.

A breech-loading rifled gun 9·448 in. bore, made in 1868 for the Dutch Government, fired 330 rounds with 56·5 and 61 lb. charges of powder, and 338·5 lb. shot. With the smaller charges an initial velocity of 1,252 ft., and with the larger one of 1,298 ft. was obtained. Several more rounds were afterwards fired from this gun, which still remains fit for service.

A breech-loading gun belonging to the Swedish artillery, 9·25 in. bore, was fired 185 rounds, the projectiles weighing 508 lbs., and the powder charges ranging from 70 to 95 lbs., the classes of powder being varied. The initial velocity was from 1,200 ft. to 1,324 ft., and the highest pressure registered in this gun was 2,640 atmospheres.

A second gun belonging to the Swedish artillery. 8·08 in. bore, fired 60 rounds, with a projectile weighing 339 lbs., and powder charges ranging from 46 lbs. to 35 lbs. The initial velocity of the projectile was from 1,300 ft. to 1,400 ft., and the highest recorded pressure in the gun was 2,730 atmospheres. This gun and the preceding remained in a perfectly serviceable condition.

From a gun 4·76 in. bore, belonging to the Swedish navy, 745 rounds were fired. In 500 of these, powder charges of 6 lbs. were employed, and with 245 rounds 6·5 lbs of powder. The projectiles weighed 37 lbs. This gun is a rifled breech-loader, and reinforced with the steel rings. With the smaller charge the initial velocity of the projectile averaged 1,310 ft., and with the larger it reached 1,360 ft. The highest pressures recorded were 1,300 and 1,750 atmospheres respectively.

A smooth-bored test gun, made in 1871 for the Swedish artillery, was intended, according to the conditions of contract, to resist at least 15 rounds, with 7 lbs. powder charges and 56 lbs. projectiles, the normal charge being 4 lbs. of powder and a 36 lbs. shot. This piece resisted during 42 rounds, bursting at the forty-third, the charges being gradually increased. The thirteen last rounds were as follows :—

			lbs.
5 with	9 lbs. of powder, and a projectile weighing	-	250
5 „	10 „ „	-	252
3 „	11 „ „	-	252

A 6-pounder, upon the Swedish artillery model of 1831, and cast as a test piece to a 9·448 in. gun for Holland, was tested to bursting in the autumn of 1870. This piece, made for a charge of 2 lbs. of powder and a round 7 lbs. ball, had, in order to guarantee the 9·448 in. gun, to resist at least 20 rounds, the charges being gradually increased, until the twentieth round was fired with 5 lbs. of powder, and a 42-lb. shot. The piece resisted 28 rounds, the last of which was with 7 lbs. of powder and a 98-lb. shot. It burst with the following round, in which 7·5 lbs. of powder and a projectile weighing 105 lbs. were employed.

A 6-pounder on the same model—a test piece for another Dutch gun of 9·448 in. bore—was tested in the same manner in 1871. It resisted 29 rounds, but burst at the thirtieth, the last charge being 8 lbs. of powder and 112 lbs. shot.

A 4-pounder test gun of the Danish model, and belonging to an 11 in. cannon made for Denmark, was tried to bursting in 1871. According to the contract this piece should have resisted 140 gradually increasing charges, of

which the five last were to be 2·94 lbs. of powder, the normal charge being 1·77 lbs., with a projectile having the weight of eleven round balls. The piece broke at the 202nd round, the seven last having powder charges of 5·29 lbs., and the projectile being equal to 13 round balls. This piece was not rifled.

A 4-pounder test piece, on the same model, belonging to an 8·08-in. gun, was tested to bursting in the same way as above. It broke at the 204th round.

In 1869 a series of trials were made at Finspong against an iron target having a total thickness of 10·2 in. It was completely perforated by the 9·448 in. diameter chilled shot, which were entirely uninjured. An additional plate 4·3 in. thick was then added, bringing up the total thickness to 14·5 in., which was also pierced by the shot. The damage done to these latter by this severe test, consisted of three fine cracks in the chilled head.

In Denmark some trials were made with a target, consisting of an 8-in. plate, with 18 in. of oak backing, and an inside plate. The Finspong shot thrown from an 11-in. gun passed through this target without injury to themselves. Similar results were obtained in France and in Holland, when 8-in. plates, with 14-in. backing, were penetrated by shot from the 9·448-in. gun.

Experiments made with the Finspong shot at Shoeburyness, compared unfavourably with the Woolwich shot tried against them.

The following list comprises the different calibres and classes of guns that have been recently made in Sweden :—

	in.		lb.
Rifled breech-loading guns	9·24	bore, and weighing	51,000
Smooth bore muzzle-loaders	15	„ „	48,300
Rifled muzzle-loaders -	11·25	„ „	48,175
„ breech-loaders -	11·25	„ „	48,175
„ „ -	9·448	„ „	34,700
Smooth bore muzzle-loaders	11·251	„ „	33,300
„ „ -	10·510	„ „	30,000
Rifled breech-loaders -	8·937	„ „	29,375
„ „ -	6·574	„ „	12,400
„ muzzle-loaders -	6·023	„ „	5,887
„ „ -	4·765	„ „	4,200
„ „ -	3·740	„ „	1,500
„ „ -	3·307	„ „	946
„ „ -	2·992	„ „	900
„ „ -	2·559	„ „	595

Besides rifled mortars 8·937 in., 9·055 in., and 11·12 in. bore.

For coast defence rifled guns 9·448 in. and 10·63 in. bore are adopted in Sweden, the smaller calibres being on two models, copied from the French systems of 1864–66.

The short 9·448 in. gun shown by figs. 3 to 13 on Pl. 225, differs from the French gun of the same calibre, in the following minor detail: the direction of the rifling grooves is from left to right, as in all Swedish guns.

The safety apparatus for preventing premature ignition is on a Swedish model, and the normal charge is 59·4 lb. of coarse-grained powder closely resembling the Belgian, powder of 13 to 16 mm. (·51 to ·62 in.) gauge; the initial velocity is 1,344 ft.

The carriage of this gun is a so-called *affût à chassis*, that is to say, it is composed of the carriage proper, and the frame of wrought iron (see figs. 1, 2, Pl. 225).

The carriage rests on four wheels, while the rear part is raised by the action of axles eccentric to the wheels. To these eccentric axles are attached two levers *a*. When towards the end of the recoil these levers come in contact with the stops *c*, the axles are turned forward, and rise through an angle of about 100 deg., placing the carriage on the slides. The levers *a* are kept in this position by the catches *b*, actuated by spiral springs. The

carriage resting now on its four wheels, returns to firing position. When it has almost reached this position, the catches are lifted by tappets *d*, and the levers are brought back to their first position, the eccentric axles falling back by the weight of the gun, and the carriage thus lowered slides upon the lower frame. The friction of the sliding movement checks any undue velocity, and brings up the gun fairly to its position.

The elevating arrangement is shown on the drawing, and is that commonly used for heavy guns, so that it needs no description here.

The carriage has four stops fixed to the lower part, the two rear ones *h* limit the recoil by their contact with the rubber buffers *i* fixed to the frame; the two stops forward *k* regulate, by coming in contact with the buffers *l* also fixed to the frame, the firing position of the gun. The angle irons *m* guide the carriage in a straight line during its recoil. The pieces *n*, which are fixed under the bottom plate of the frame, serve to prevent the lifting of the forward part of the carriage during the recoil.

The main bearers of the lower frame are double T-irons, rivetted to and covered with plates, so as to form the sliding surfaces for the recoil. They are inclined forward about 5 deg. There are four wheels to this lower carriage, running on circular rails; they are of cast iron, and so arranged that the recoil is transmitted to them direct, this system having no forward pivot.

The hydraulic brake is of a well-known form. Its principal part is the cylinder *p*; this cylinder is closed at both ends by the covers *r*. The piston rod is shown at *q*; and the piston is pierced with four holes. The cylinder rests on three bearers, and is secured by cross straps, taking an abutment against blocks attached to the bearers. It is partially filled with glycerine, the quantity being determined by experience. On the floor of the casemate is placed a curved rack, concentric with the carrying rails, and placed almost in the plane of the centre of gravity. Into this rack gears a pinion *s*, the axis of which is in the vertical plane of the middle of the carrying frame; it runs in brass bearings, attached at *t* to the forward part of the frame. On the same axis is placed a second toothed wheel *u*, gearing into an endless screw, the ends *x* of which project beyond the frame, and carry the toothed wheels *v*, which are operated through gearing by the lever *w*. In the event of this system being fractured, the rear wheels of the frame are made with holes, so that the gun can be trained by levers.

To run back the carriage, rings are provided on each side of the frame, through which ropes are led around pulleys fixed to the rings *o* of the carriage, as well as around the pulleys *y* of the frame, the rope being then fixed to the friction disc *x*, forming a part of the toothed wheel *v*, which is free to turn around its axis when a key is withdrawn. Two men on each side operating the levers *w* can run back the carriage.

The long 9·44 in. gun differs from the short piece of the same calibre in the following particulars. The length of the bore in the former is 19 calibres, and in the latter it is only 17·4 calibres. The rifling is 13·38 in. longer, the weight is 30,709 lb., and the preponderance is 600 lb. This class of ordnance is as yet only in an experimental and unfinished stage. The projectile is similar to that for the short piece, but the charges are not yet finally settled. The construction of the carriage is in all respects the same as for the short gun of the same calibre.

The 10·63 in. gun recently introduced into the Swedish service, differs from the French gun of the same calibre in length, which exceeds that of the French model by 2·7 calibres, while the length of rifling is 102·25 in. The direction of the rifling is from left to right. The weight of the gun is 52,927 lb., and the preponderance is 308 lb. A number of guns upon this type are now being manufactured at Finspong. See fig. 14, Pl. 225.

The chilled projectiles weigh 475·2 lb., and the charge will probably be fixed at from 85 lb. to 96 lb., the initial velocity calculated from experiments made with a gun with a length of bore of 15·3 calibres, should be about 1,344 ft.

Powder employed in the Swedish Heavy Ordnance.—The high pressure developed by the combustion of the old small-grained powder in guns of large

calibres, led in Sweden as elsewhere, to a change in the form of the explosive. After numerous experiments completed about three years since, it was decided to adopt powder very similar to that employed in Belgium, of which the grains are from ·511 in. to ·629 in. across, but with certain modifications, founded upon the results of the experiments above referred to. The composition of the powder is as follows :—

	Per cent.
Saltpetre	75
Charcoal	15
Sulphur	10

The size of the grains is the same as in the Belgian powder, the density being 1·70 measured in mercury, the peculiar quality of the Swedish charcoal having rendered this density necessary.

During the trials just mentioned, the gas pressures were obtained by the crusher gauge, and the initial velocities were obtained by Boulengè's electro-balistic apparatus. In the case of the short 9·44 in. gun the following results were obtained :—

Nature of Powder.	Charge.	Initial Velocity.	Maximum Pressure at the Breech in Atmospheres.
	lb.	ft.	
Common small grain	52·8	1,239	3,000
Swedish large grain	59·4	1,344	More than 1,570
Belgian	59·4	1,354	1,965
Pebble powder	56·10	1,285	1,760

Field Guns.—Since 1864, the artillery of Sweden has comprised cast-iron muzzle-loading rifled field guns. They are of three different calibres, 3·779 in., 3·031 in., and 2·637 in.,* (Pl. 226,) and are all rifled with six grooves, three of which, deeper than the others, serve as driving grooves, while the other three facilitate loading.

The shell and shrapnel of the first patterns (1863) have only two rows of studs, the three forward ones giving the rotation, and the three rear ones supporting the shot, and we may, for the purpose of describing the grooves, take this type. The shallow grooves are continued almost as far as the powder chamber, to receive the rear projections on the shot, whilst the deeper grooves extend only far enough to receive the forward studs of the projectile. When the latter is introduced, the bearing studs touch the bottom of the grooves (see figs. 5, 6, 7, Pl. 226), and as the directing studs come into play during the passage of the projectile in the gun, they bear against the sides of the grooves, and insure regularity in firing. The advantage in employing supporting studs less prominent than the directing ones, consists in the fact that the deep grooves can be stopped short of the chamber, as mentioned above, and experience has shown that the piece is much strengthened by doing so. For the field-guns, shell and shrapnel are employed, as well as fire shells, and mitraille cases. The shells are provided with percussion, and the shrapnels with time fuses, the latest form of shrapnel having only two rows of studs, whilst the shells have three rows. At the time when the length of the projectile was increased, two rows of directing studs were added to the shell, and by this the correctness of practice was greatly increased.

Both percusssion and time fuses are employed; the firing point of the latter is at the head, experiments having shown that to be the best position.

* Only a few 2·637 in. guns have been made, and now they are altogether abandoned.

The following table gives data relating to the weight of the gun, projectiles and charges, as well as of initial velocities :—

	Field Guns.	
	3·779 in.	3·081 in.
Total length of piece in calibres -	19·5	22·4
„ „ barrel „ -	18·5	21·3
Maximum thickness of metal in calibres.	1·105	1·1
Minimum thickness of metal in calibres.	0·47	0·49
Inclination of grooves - -	4 deg. 28 min.	4 deg. 28 min.
Weight of gun - - -	1,408 lb.	836 lb.
Service powder charge - -	2·794 „	1·694 „
Weight of common shell loaded -	17·2 „	8·66 „
„ shrapnel „ -	17·53 „	8·69 „
Number of balls in shrapnel -	140	53
Initial velocity - - -	1,203 ft.	1,179 ft.
Average deviation in range of 3,280 ft.	29·5 „	36 „
Average deviation in range of 6,560 ft.	52·5 „	54·5 „
Average deviation in direction with range of 3,280 ft.	16 in.	19 in.
Average deviation in direction with range of 6,560 ft.	3 ft. 7 in.	3 ft. 7 in.
Angle of elevation with range of 3,280 ft.	2 deg. 23 min.	2 deg. 25 min.
Angle of elevation with range of 6,560 ft.	5 deg. 45 min.	5 deg. 49 min.

With a few exceptions the carriages, limbering, &c., of the Swedish field guns are of a very antique pattern, dating back to the models of 1831, and as they are about being replaced by others of a modern design, it will be more interesting to refer briefly to them than to describe the others, which have long passed out of date.

The carriage and limbering are made chiefly of wrought iron, the wheels of each being of the same dimensions (figs. 3, 4, Pl. 226). The elevating screw is connected to the breech of the piece by a bolt, and is operated by a hand wheel and bevel gearing. Resting on rubber pads, are placed two chests on the axle of the carriage, the covers of which form seats for the men in charge of the gun. The left-hand box is for the reception of mitraille cases, the right is for a telemeter. A small intermediate case holds different tools. The carriage is attached to the limber by means of a swinging hook and bolt. The ammunition chest is of wood with a cover of sheet iron. The limber is common to the gun carriage and the caisson. The train of the latter is of sheet iron, and the wheels are similar to those of the carriage. The following table gives the leading dimensions of the carriage, &c.:—

Height above the ground to the centre of trunnion -	40·94 in.
Maximum angle of elevation - - -	15 deg.
„ depression - - -	8 „
„ revolution - - -	87 „
Width of carriage - - - - -	5 ft.
Diameter of wheels - - - - -	57·87 in.
	lbs.
Weight of carriage - - - - -	952
„ „ and gun - - - -	1,788
„ limber - - - - -	917

			lbs.
Weight of ammunition in limber	-	-	286
Total weight of piece with ammunition, equipment, and men	-	-	4,114
Weight, per each horse of the battery	-	-	686
Number of projectiles in the limber :			
Common shell	-	18	
Shrapnel	-	18	
Number of projectiles in the chest on the gun carriage :			
Mitraille cases	-	3	
The caisson :			
Maximum angle of revolution	-	-	70 deg.
Width	-	-	5 ft.
			lbs.
Weight	-	-	1,348
„ of ammunition	-	-	1,152
Total weight, including equipment, men, &c.	-	-	4,998
Weight per each horse	-	-	833
Number of projectiles carried :			
Common shell	-	48	
Fire shell	-	6	
Shrapnel	-	42	
Mitraille cases	-	15	

In the construction of the carriage for the 3·81 in. gun, iron will be also employed as the chief material. The construction of them, however, has been suspended for the present for the following reasons : Instead of the ordinary service of eight horses for pieces of this calibre, it is desired to reduce the number to six, but as this can only be done by reducing the weight of the carriage, it is proposed to make these pieces of steel instead of cast iron, and to this end experiments were to have been commenced early in the present year.

The Reffye Field Gun.

One of the most interesting pieces of field artillery in the Vienna Exhibition was the bronze breech-loader invented by Lieutenant-Colonel Reffye, of the French Artillery, and mounted for view near the Machinery Hall entrance to the Rotunda.

Before the late Franco-Prussian war, the defects of the service field artillery were recognised by the French Government, and experiments on new guns were instituted with the ultimate view of selecting an improved weapon. The only gun which was even partially tried before the war broke out was the Reffye "canon de 7," which was made at Meudon and experimented on at Versailles in the month of June 1870.

At the capitulations of Metz and Sedan, the French army lost the greater part of its artillery, and the task of supplying their raw levies with a new weapon which should cope with the Prussian field guns devolved upon the Government of the National Defence. Their choice fell upon the Reffye breech-loader, and before the close of the war over 2,000 of these weapons were manufactured, which rendered good service during the Prussian siege of Paris and the rebellion of the Communists which followed after.

In the beginning of 1873, a series of experiments on guns of this system was carried out at Calais with very satisfactory results. Since then the "canon de 7" has been adopted definitely as the principal arm of the French field artillery The gun is made wholly of bronze, its general shape being cylindrical from the breech as far as the trunnion ring, and conical from thence to the swelling at the muzzle.

Its principal dimensions are as follows :

Calibre	-	3·5 inches.
Diameter of powder chamber	-	3·642 „
Total length	-	79·214 „
Length of bore	-	73·8 „
Weight of gun	-	12·6 cwt.

The bore is rifled with fourteen grooves, having a depth of 1·5 millimetres, and a uniform twist of 5° 44′. The breech closing arrangement consists of the screw with portions of the thread removed, which has been already alluded to. When the screw is withdrawn from the breech it rests in a steel ring, let into the end of the gun, and mounted on hinges like a door, so that it can be swung back, thus leaving the passage to the chamber free. The touch-hole is drilled obliquely through the screw in such a position that if the latter be not securely driven home, the mouth of the touch-hole lies hid behind a covering plate fastened to the steel ring, and the charge cannot be ignited. Accidents are thus rendered impossible. See Pl. 224.

The cartridge case is very remarkable, serving as it does not only to enclose the powder charge, but also to prevent the escape of gas through the breech screw and the touch-hole. It moreover prevents the powder chamber from becoming unduly heated. With these ends in view, the case is made up of three distinct parts, namely:—

1. A cup-shaped base of sheet brass, which when the explosion takes place is expanded like a Bramah collar, so as to close completely the touch-hole, and also the lines of contact between the breech screw and the base of the powder chamber.

2. A cylindrical body of tin-plate, which is covered within by four coils, and without by three coils of paper.

3. A cylinder of strong pasteboard which unites together the cup and the body.

The two last named parts not only strengthen the cartridge case, but act also as non-conductors which prevent the chamber from becoming heated, and moreover save it from the erosion due to the action of the powder gases. See Pl. 224.

The cartridge case is extracted after each round by a very simple contrivance. The head of the breech screw is hollowed out so as to form a shallow truncated cone, and in the side of the cone three spiral scores are cut. When the explosion takes place the cup-shaped base of the cartridge is blown into this hollow cone, and the soft brass is imprinted into the scores so firmly that on the screw being turned round and withdrawn it carries with it the whole case. It would seem at first sight that the metallic body of the cartridge would expand so tightly against the sides of the chamber as to render the withdrawal impossible. This difficulty, however, is prevented by leaving the seam in the metal cylinder unsoldered, and covering it simply by a metal strip, which of course allows the cylinder to spring without becoming permanently expanded, while the strip, together with the pasteboard and cartridge paper, maintain the case gas-tight.

The ordinary charge consists of five rings of cake powder, formed by compressing common gunpowder till the specific gravity is 1·615. The rings have an internal diameter of 52 millimetres, and are placed one above the other, so as to form a hollow cylinder the weight of which is 1·130 kilogrammes. The head of the cartridge is occupied by a disc of grease enclosed in a pasteboard cup.

The projectile is a common scored cast-iron shell weighing 6·9 kilogrammes = 15·2 lbs., the length being three times the calibre. Originally it was enveloped with a continuous lead jacket to take the rifling. This has now been done away with and two leaden rings substituted. Experiments on the projectile seem, however, still to be pending, and as these are not completed it would be useless to go into the matter further.

The Reffye gun has recently been subjected to an exhaustive series of experiments at Calais by a commission of French artillery officers, the results of which have been chronicled in the "Révue d'Artillerie" by the Chef d'escadron Mercier, one of the members of the commission.

The following are some of the results as regards range, elevation, and time of flight, the charge and projectile being the same as those giving above and the initial velocity being 390·3 metres.

Time of Flight.	Angle of Descent.		Angle of Elevation.		Range.
secs.	deg.	min.	deg.	min.	
0·53	0	25	0	12	200
1·12	0	56	0	38	400
1·66	1	31	1	7	600
2·28	2	9	1	39	800
2·91	2	51	2	12	1,000
3·95	3	34	2	47	1,200
4·27	4	19	3	24	1,400
4·95	5	5	4	2	1,600
5·68	5	53	4	41	1,800
6·43	6	41	5	21	2,000
7·19	7	33	6	2	2,200
8·00	8	26	6	45	2,400
8·82	9	21	7	29	2,600
9·66	10	16	8	14	2,800
10·54	11	20	9	0	3,000
11·45	12	27	9	48	3,200
12·36	13	40	10	38	3,400
13·37	15	0	11	30	3,600
14·37	16	29	12	25	3,800
15·38	18	8	13	23	4,000
16·49	19	58	14	25	4,200
17·61	22	3	15	31	4,400
18·80	24	23	16	43	4,600
20·08	26	59	18	1	4,800
21·43	29	51	19	27	5,000
22·88	33	5	21	3	5,200
24·47	36	40	22	51	5,400
26·40	40	45	24	55	5,600
28·39	45	1	27	26	5,800
30·62	49	5	30	28	6,000

These results were considered eminently satisfactory, and as regards accuracy in shooting, the weapon leaves little to be desired.

The breech-loading apparatus, which appears to be simple and yet efficient, worked admirably throughout.

The same remark applies to the metallic cartridge cases. As an instance of the value of the latter in saving the chamber from deterioration it may be mentioned that after a sustained fire, first of 115 and then of 240 rounds, although the muzzle became extremely hot, the breech never exceeded a very moderate temperature, and could always be touched by hand without the slightest discomfort. Upon the whole the French Government and Colonel Reffye must be congratulated on having produced results which have never yet been surpassed by any bronze field gun.

Miscellaneous.

An examination of the wonderful collection of breech-loading ordnance brought together at the Vienna Exhibition showed a remarkable fact—that, with the exception of the insignificant display made by France, and the guns shown by Sweden, in which country, as we have seen, the French mode is adopted, all the breech-loading ordnance exhibited was upon one system only. A further exception may, however, be made of one large naval gun shown in the Russian pavilion, in which the French system was also adopted. Bearing in mind, that, with the exception of England, the whole of Europe is armed with breech-loading ordnance in all calibres, we shall be able fully to appreciate the singular uniformity of system which has found so extended an application; while, looking beyond the continent, we find that many other countries are armed with the same weapon, the use of

which is almost universal. The system thus so widely extended is ostensibly Krupp's but in reality that of Mr. L. W. Broadwell, an American engineer, established, however, for many years in Germany.

Few people have any practical notion of the construction of the breech-loading system in question, and to still fewer is the history of its development known. The whole story is a striking illustration of the imperfect working of the German patent law; it is, besides, a singular history of injustice to an individual who has been at once deprived of the chief parts of the credit and the profit, arising from his invention, thus utilised by the most celebrated manufacturer of ordnance in the world. What renders the case yet more striking is that Mr. Broadwell is no needy inventor, but the manufacturer of ordnance on his own system, upon a large scale, at Carlsruhe, and that his claims are fully acknowledged in France, Russia, Austria, Turkey, Italy, and Switzerland, several of which countries have paid him large sums for his patent rights.

To follow the story up thoroughly, we must go back as far as July 1861, in which month Mr. Broadwell obtained his first English patent, but it may be well first to repeat in a few words the arrangement of the breech-closing mechanism, as it is at present so widely used. This mechanism may be applied to any gun, the breech of which is sufficiently extended to admit of a slot somewhat larger than the bore and at right angles to it, being cut through it. This slot is of such a form as to receive the so-called cylindro-prismatic wedge block, through one end of which a hole is formed of the same diameter as the chamber of the gun, while to the other end is attached a screw, of which the thread is partially cut away. To this screw is attached a shaft and cross handle. The position of the screw on the breech block is such that the threads project beyond the rear face of the block, and suitable recesses are formed to receive them in the breech of the gun itself. It will thus be evident that by turning the screw partly round so that the portion cut away comes to the rear of the block, the latter can be drawn out until the hole through the other end comes opposite the chamber of the gun, which is thus in a loading position. Further movement is checked by a stop. On pushing home the breech block, a partial turn of the screw locks it into the breech of the gun, rendering further motion impossible when the gun is fired, although to counteract any possible tendency of the shock to turn the screw, the handle of the latter may be so counterweighted that the jar shall tend always to tighten the block in its place. In the front face of the breech block is a circular recess, considerably larger than the chamber of the gun. In this recess is fitted a copper disc, and above it a steel circular plate exactly fitting the recess. The end of the chamber of the gun is considerably enlarged in diameter, this enlargement corresponding exactly with the diameter of the bearing plate in the breech block. The recess thus formed is not cylindrical but spherical, and it receives the spherical gas ring, which forms a vital point of the arrangement. The ring is made to fit the recess exactly, and its periphery forming a portion of a sphere, it is evident that it can always adjust itself, preserving at the same time perfect contact with its seat. The back of the ring is made broad and flat, and bears against the plate before mentioned. On its rear face a series of concentric grooves are cut to receive and retain any grains of dust or other impurities which may otherwise get between the back of the ring and the face of the plate, and make the contract imperfect.

We have said sufficient to give a general idea of the construction of the arrangement, and presently we shall further consider it with the aid of detailed drawings. It will be seen that the most valuable specialty of the invention consists in the combination of a self-adjusting spherical gas ring, with an adjustable circular bearing plate, which together form a perfectly gas-tight joint, and which can be repaired at an insignificant outlay both in time and money.

To return now to the first English patent of Mr. Broadwell. This is dated the 19th of July 1861, and was granted for various improvements in breech-loading ordnance. It contained the application of the sliding breech block somewhat as just described, with details for locking the same, naturally crude as compared with the latter device. The most important feature, however,

was the insertion in a chamber in the face of the breech block of a cylindrical metallic gas ring. In the month of October following, drawings of a gun as patented, were submitted to Mr. Krupp, from which to form an estimate for the construction of some trial pieces. The order for these guns was, however, declined. On the 20th of February 1863 an English patent was sealed to Mr. Krupp for certain improvements in breech-loading ordnance, conspicuous amongst which was the insertion in a chamber in the face of the breech block of a cylindrical metallic gas ring, precisely similar to that patented by Mr. Broadwell in 1861. That a patent for this detail was ever granted to Mr. Krupp is a scandal to our patent system.

Prior to this introduction by Broadwell of the metallic gas ring in all the different systems of Prussian breech-loading guns—the Wharendorff, Kreiner, and Krupp—a papier-maché cup was attached to the rear of each cartridge bag, to check the escape of gas at the breech, and the various inventors had confined their efforts to mechanical devices for opening and closing the breech of the gun, the aforesaid papier-maché cup being always used.

The property of Mr. Broadwell in the metallic gas ring was, we may mention in passing, entirely ignored, and served as a commencement for subsequent unacknowledged appropriations by Mr. Krupp.

In 1863 Mr. Broadwell patented a very notable improvement in his system. This was the adoption of a conical, instead of a cylindrical ring, placed, not in a recess in the face of the breech block, but in a conical chamber in the rear of the breech of the gun, the recess in the breech block being filled up with an adjustable bearing plate in contact with the back of the conical gas ring. In 1865 he completed his patent for operating the breech-block by the screw with the cut-away thread.

Early in 1864 a working model, embodying the features of this patent, as well as (for the first time) the cylindro-prismatic breech block, was made, and submitted to Mr. Krupp, with the view of entering into arrangements by which a royalty should be secured to the inventor, provided that Mr. Krupp should undertake the manufacture—a probable matter, judging from the past experience of the cylindrical gas ring. In answer to this application, however, reply was received from Essen, declining to enter into any arrangement. On the other hand, Messrs. Berger, of Witten, who have subsequently manufactured large numbers of these guns, recognising the right of personal property in invention, paid a royalty to Mr. Broadwell upon all guns they produced upon his system.

Going then to St. Petersburg, Mr. Broadwell submitted the model alluded to, for the consideration of the chief of Russian Artillery, and almost simultaneously with his arrival came 100 4-pounder field guns from the works at Essen. Of these, 50 were provided with the Kreiner double-wedge breech block, and the remainder with the ordinary single wedge, but all of them were fitted with a cylindrical metallic gas ring in the face of the breech block, precisely as described in the 1861 patent already noticed.

At the request of Mr. Broadwell one of these guns was altered to the form patented in 1863. A conical ring was introduced at the base of the chamber, and the recess in the face of the breech block was filled with an adjustable bearing plate, whilst the screw fastening was substituted for the clumsy double lever arrangement then made by Mr. Krupp, the only difference being that the form of the breech block was not altered, as the gun was not suited to it. This converted gun was then submitted to a long series of tests with the ordinary pieces, and these experiments resulted in the entire adoption of the Broadwell system by the Russian Government. It was during the progress of these trials that Mr. Broadwell arrived at the latest and most important improvement in his system, namely, the substitution of a spherical, instead of a conical, ring, for the gas check, as already described. The value of this detail was at once appreciated by the Russian Government, which adopted at once the entire system for all calibres, and which has not made the smallest alteration in its details after eight years of experience.

Large orders for the Broadwell gun from the Russian Government to Mr. Krupp, quickly followed the purchase of the patents, and from that time no breech-loading gun of any other form has been turned out at Essen, although

the inventor has utterly failed to obtain any acknowledgment from Krupp as to his property of the invention, beyond the fact that the spherical gas ring is called, even at Essen, the Broadwell ring, although no royalty has ever been paid for its use. More than this, patents were taken out in this country by Mr. Krupp, bearing the date December 7, 1868, for so-called improvements in breech-loading ordnance, which practically embody the details in Broadwell's model of 1864, and the drawings supplied by the Russian Government with their first order in 1865, or the beginning of 1866.

It should be mentioned in conclusion that shortly after obtaining his patent in 1861, Mr. Broadwell submitted his plans to the Prussian Minister of War, soliciting a trial of the system, and asking that, if successful, its adoption should follow. An absolute refusal to entertain this proposition was returned to the application, but shortly after, a large number of guns were fitted with the cylindrical ring in the face of the breech block, in principle identical with the drawings of Mr. Broadwell. These guns were largely used during the war with Denmark, when the results obtained were so satisfactory, that its universal adoption was ordered, without, however, any reference to the claims of the inventor.

Again, in 1865, after the introduction of the spherical ring, an application was again made to the Prussian War Office, strengthened by the representations of the American Minister at Berlin. The official reply to this application was to the effect that, having made a similar device six years before, a priority of invention rendered Mr. Broadwell's claim invalid. If this was true, it was unaccountable that so valuable a device was allowed to remain unused for so long a period, only to be employed after Mr. Broadwell's plan had been submitted. After some official trials that were made with the spherical ring at Tegel, instructions were issued for the adoption of the system throughout the service for heavy calibres, and in direct contradiction to the assertion of prior invention, as an excuse for evading the claims of Mr. Broadwell upon the Government, the spherical ring is called universally in the official works on artillery published by the Prussian War Office, the "Broadwell ring," a full and sufficient acknowledgment of the originality of invention that had been previously denied.

Such is the story of the European breech-loading system as borne out by patent specifications and official and authentic documentary evidence. Appropriation of invention was, it is true, seen on every side among the German exhibits at the Vienna Exhibition, though in no other instance on a scale so gigantic. Yet we have seen, as in the case of Messrs. Berger, of Witten, that some German manufacturers do acknowledge the proprietorship of invention, and it appears extraordinary that a manufacturer on so vast a scale as Mr. Krupp should not only decline to pay fairly for the invention by which he has profited so enormously, but should also decline to acknowledge the proprietorship. Probably Mr. Krupp has, personally, remained hitherto in ignorance of the facts of the case, and had he been acquainted with them, his share in the events we have recorded would never have taken place.

Besides, however, our desire to show by this most striking example, the necessity for an improved legislation on patents in Germany, we have wished to establish the position due to the originator of the system of breech-loading ordnance, adopted, as we have seen, by most of the leading powers in Europe and largely employed in South America, in China, and in Japan, and whose name is also widely known for his improvements in the Gatling gun and mitrailleuse.

We may now proceed to notice further the construction of the Broadwell gun, of which illustrations of various calibres are given in Pls. 227, 229; figs. 3 to 9, Pl. 227, are details of the various parts of a gun built by the Bochum Company; and figs. 10 to 13, Pl. 224, illustrate a 6-pounder gun. Fig. 10 is an elevation of the rear end of the gun, showing the back of the breech block, and the chamber in which it slides; fig. 11 is a longitudinal section, in which the block, copper disc, and plate are shown, together with the spherical gas ring. Fig. 12 is a plan of one side of the gun, showing the end of the cylindro-prismatic block, and the locking lever. The mechanism

for locking and unlocking the breech block is more clearly shown in the section, fig. 13, which is taken horizontally through the block and shows its form. The partially cut away locking screw is shown in section in this figure.

Amongst the miscellaneous exhibits we may include the good show made by the Bochumer Verein of Bochum, Westphalia, and comprising a 21 centimetre (8·268 in.) naval gun of the ordinary form of construction, supplied like all Krupp's gun with the Broadwell breech-loading arrangement. This gun was tested by the Prussian artillery Commission with 500, and afterwards with 50 rounds, the first series having regard to the durability, and the second to the absolute strength of the gun. The results of the trial were in all respects satisfactory, and with the ordinary charges an average range of 8,740 yards was obtained.

Two field guns were exhibited by the same company, 3·149 in. and 3·543 in. calibre. These formed part of a large order executed for the Turkish Government by Mr. Broadwell, who as time was pressing, obtained the assistance of the Bochumer Verein in the contract. Fig. 3, Pl. 229, illustrating one of Krupp's field guns, represents substantially those shown by this company.

Several Broadwell guns were also shown by the manufacturing establishment at Witten, formerly Messrs. Berger and Co.

Mitrailleuses.

A short notice of the mitrailleuses and small arms exhibited will complete the present section. Of the former the Montigny and Gatling guns were shown, the latter possessing many improved details perfected by Mr. Broadwell. Figs. 13, 14, Pl. 218, show a mitrailleuse exhibited by Sigl of Vienna, with the shield of plate iron in front, which folds back so as to form a seat for the gunners when the piece is in transit. This detail belongs to Mr. Broadwell, and is shown in figs. 1 to 7, Pl. 228. where the shield is applied to a gun mounted on carriage designed by Mr. Broadwell. It also combines an apparatus for maintaining an automatic right and left hand movement of the barrel for horizontal firing. See figs. 8 to 13, Pl. 228.

The axle of the main frame which is mounted upon wheels supports an angle and plate iron frame to hold the trunnions of the gun and to admit of the barrels being elevated or depressed by a screw, at the rear. The trunnion plate is pierced at or about its centre for the reception of a pin or perch bolt, which is kept in place by passing through a bottom plate fitted underneath. This plate is carried to the rear where it is provided with a curved slot or with a curved plate, through which a pin on the bottom of the breech piece or ring passes, the radius of the curve being struck from the perch bolt, so that the barrels can be directed laterally to the right or to the left as desired for divergent firing, and without in any way interfering with the elevation for distance firing. This plate has a projecting piece for supporting a vertical pin or standard to which a spring clutch or disengaging apparatus is fitted, the prongs or fork of the clutch taking into a double endless screw on the crank shaft which determines the loading and firing operations. By this means, when the clutch is engaged and the crank shaft rotated, an automatic right and left motion of the barrels takes place as well as the continuous loading and firing of the charges. There is a tightening disc and nut on the end of the shaft, and the disc is formed with a conical collar to fit in a corresponding recess in the screw; these, when pressed together, compel the two to partake of the same movement, otherwise the screw is loose upon the shaft and remain idle. By this means the gunner in charge can in an instant direct the bullet in any direction right or left or straight ahead by simply loosening the disc, or if the disc is left fastened a continuous right and left motion continues so long as the shaft is turned. Instead of the disc, a rising and falling lever may be used, and the end of the screw may be shaped to alter the angle of the fork or clutch for reversing the stroke at the end of each travel. The fore end of the gun or frame is provided with the folding shield (bullet proof) the flaps of which can be raised or lowered to form seats for the men when

travelling, or fixed in position by catch hooks for action. In the drawing, fig. 1, Pl. 228, represents a side elevation of a mitrailleuse with one of the wheels removed to show the parts more clearly; fig. 2 is a transverse section of the gun taken just in front of the axle and trunnions; fig. 3 is a detached edge view of the shield, and fig. 4 are details of the traversing mechanism. The axle *a*, mounted upon wheels *b b*, has at its central part the bearings *d d*, of the trail *e*, composed of angle and plate iron *f*, *g*, for supporting the socket or bed plate *h*, in which the trunnions *i i* of the gun are held, the trunnions being part of the recessed strap *j*, through which the perch bolt *k* passes to hold the gun *l* in position as on a pivot, the bolt *k* also passing through, a bracket in which rests upon the strap *j*; below the strap *j* a plate *n* is bolted, the after end *o* of which is slotted for a pin *p*, under the breech portion of the gun to slide to and fro in when the automatic traversing motion is being transmitted to it by the clutch *q* riding in the threads of the double endless screw-threaded collar *r*, the collar being on the spindle of the breech-block rotating mechanism so that it partakes of the movements of the crank handle *s*. The rotation of the collar *r* with the spindle is controlled by a screw button *t*, on the end of the spindle, the button having a conical face to enable it when turned to approach the collar to bend itself by the nut *n* on the extreme end of the spindle so as to hold it secure. The top of the breech portion *v* is shaped to receive a drum of cartridges, and the trail is so arranged that additional drums can be carried in the boxes *w w*, which are mounted upon the main axle *a*, so that a continuous fire can be kept up, the boxes being arranged so as not to interfere with the working of the gun. The boxes are fitted with straps *x*, which have projecting lugs for supporting the central plate of a shield *y*, which stretches across and almost fills up the space between the wheels *b b*, for the purpose of protecting the gunners at the rear who may be manipulating the mechanism and directing the gun. This central plate is a fixture, and has at top and bottom other plates *z z*, hinged to it, the lower one of which reaches down to the ground to protect the legs of the men, and the upper one reaches above their heads and protects the upper parts of their bodies and heads. The top plate is provided with clip hooks which fall into eyes on the central plate, and these hold it firmly when in a vertical position as will be seen by reference to figs. 2 and 3. On unhooking the clips the top plate can be laid over for its edge to rest upon the top of the gun, as seen in fig. 4, where it forms a seat for the gunner when travelling over the fields or from place to place. The lower plate can be turned up towards the muzzles of the barrels, and there retained by hooking it to a short chain provided for the purpose; this lower plate when turned up forms a rest for the feet of the men, and they are prevented from falling from the seat by handrails which are fitted on the top plate or seat.

The second appliance in connexion with the gun is the vertical feed-drum also designed by Mr. Broadwell of Vienna, and shown in figs. 14 to 17, Pl. 228.

The apparatus consists of a circular revolving cartridge holder, provided with partitions for keeping each column of cartridges in a separate division, from which they are taken by the charge chambers of the barrels in succession as they arrive under the opening in a stationary bottom plate of the holder. The cartridges are arranged in the divisions one above the other, and the rim of each alternate one rests upon the bodies of the adjacent ones, so that they lie in a zigzag position, and therefore assume and maintain a horizontal position, so that, as they descend to the bottom of the division each one is in readiness to be caught by the charge chambers of the barrels as they come round. A weight in each division is caused to bear upon and slide down a groove provided for it, so that it follows the cartridges, and prevent them ticking or becoming choked in the divisions. The divisions are arranged round a central tube, which forms a socket for dropping on to the pin or stud of a table or plate over the charge chambers. The table is recessed for a projection on the bottom plate, coming directly over the chamber opening. The aperture in the table through which the cartridges fall in their way to the chamber, is inclined on the two sides to narrow the space, and thus lead the cartridges singly to the bottom of it, and in order to prevent the bullet end

dropping soonest by reason of its superior weight one of the ends of the aperture is inclined, which creates a friction on the top of the bullet and checks its tendency and ensures the cartridges entering the barrels horizontally.

Fig. 14 is a view of the drum shown partly in section; it is cylindrical in form with a central tube *a a*, forming the support to a series of partitions *a b*, which are fastened to it and to each other for dividing the body into a number of compartments into which the cartridges are placed. The tube *ba*, is connected at the top to a cover or end piece *c*, which is provided with a handle *d*, so that the holder can be lifted on and off the gun, or be moved from place to place as desired. Each of the partitions consists of a plate bent at the middle to bring the two ends nearly together, so that it takes nearly the shape of the cartridge intended to be placed within it, the two ends are then again bent to bring the ends closer together, but not so close as to touch; by this means a space is left for presser plates *f f* to slide up and down in, as required. The outer edge of this plate serves as a thumb piece for moving it, whilst the piston inside the compartment acts a weight and compels the cartridges to fall as the lower ones are removed by the barrels or by a block in connexion with them. The lower end of the central tube *a a*, has a ring *g g* on its inner face which forms an abutment or shoulder for holding the ring between a bottom plate g^1 and a socket *h*, so that the holder can be moved round when it is placed on the table or top plate *i* of the gun, as shown in fig. 1. The bottom plate g^2 is perforated, or has an aperture *j* at one part of it, as seen at fig. 15, which aperture comes over the opening in the table to allow the cartridges passing to the barrels, but the plate *g* is held in one position of the table by the step or rib *k*, dropping and taking into a groove *l* in its top. The outer end of the rib is pierced and forms one half of the hinge joint, the other half being composed of a plate acting as a locking piece or catch *m*, to prevent the holder revolving in one position, that is when the handle *n* is up, as seen in fig. 14, but admitting of it being moved intermittently by the thumb as the compartments are emptied of the cartridges, when the pressure of the operator's finger is exerted against the rib, the holder being provided with a plug p^1 which enters the socket *h*, and forms a means of holding it steadily thereon during the firing of the arm. The plate is hinged to the barrel frame *q* at one side, and it passes over the rear of the barrels and terminates in a catch arrangement to fix it in a firm manner, it being fitted with a lever catch *r*, which takes into a notch in the opposite frame *s*, as shown in figs. 16 and 17, which are respectively a sectional elevation and a plan view of that portion. When it is found necessary to turn the top plate over or up to examine the breech end of the barrels the lever *t* is moved to one side to release the catch *r* from the notch.

The opening h^1 in the table is of a tapered form, and its two sides *x x*, guide the cartridges down to the block singly, so that they can be removed one by one; this is important for the perfect and regular action of the gun. The piece or front end *y* of the feed hole *h*, is projected down into a groove in the carrier block *u*, next the barrels, and thus serves to cut off the entrance to that particular barrel which is in front of it whilst in this position, and prevents the cartridges which lie upon the one already in the groove of the carrier from sliding forward and prematurely entering slightly into the opposite barrel, which, if allowed to occur, as heretofore, will cause a jam and stop the firing. The push piece is of the usual shape and form and is so made that it acts as an extractor for removing the empty cases from the barrels after their discharge in the ordinary manner.

The Gatling gun shown in fig. 18, Pl. 228, consists of a set of ten barrels in combination with a groove cartridge carrier and a lock cylinder, these parts being all rigidly secured to a central longitudinal shaft. The grooves in the carrier, the holes in the lock cylinder, and the barrels all correspond in number. Each barrel is furnished with a lock which works in a chamber formed in the lock cylinder on a line with the axis of the barrels. The lock cylinder is surrounded by an outer casing connected to a framing which is carried along both sides and across the front of the gun, the latter part carrying the fore-sight. There is a vertical transverse partition in the casing,

into which the main shaft, which carries the lock, carrier, and barrels is journalled. At its front end this shaft is also journalled in the front part of the framing. On the rear end of the main shaft is fixed a revolving gear which is worked by a handle on the right side of the breech chamber. The rear of the chamber in which the gear is placed is closed by a cascable plate having an opening through which the locks can be withdrawn and replaced when necessary. The opening is closed by a plug of special construction attached to the piece by a chain. In front of the breech casing and hinged to the frame is a curved plate which partially covers the grooved carrier, and which forms a hopper through which the cartridges are fed to the gun from feed cases. The cocking apparatus is fixed to the framing of the gun on the right hand of the lock-cylinder casing. The framing, which is fitted with elevating and traversing gear, is mounted on a gun carriage of the general form used for field guns, but of special construction in detail.

The operation of working the gun is very simple; one man places a feed case filled with cartridges into the hopper, whilst another turns the handle. By means of the gearing the main shaft is revolved, carrying with the lock-cylinder, locks, carrier, and barrels. As the gun is rotated the cartridges one by one drop into the grooves of the carrier from the feed cases, and instantly the lock is moved forwards to load the cartridges into the chambers of the barrels. By means of the cocking device acting on the lock, the cartridge is exploded, and as soon as the charge is fired the lock, as the gun is revolved, is drawn back, bringing with it the shell of the cartridge which is dropped on the ground. It will thus be seen that when the piece is rotated, the locks in rapid succession move forward to load and fire, and return to extract the cartridge shell. In other words, the whole operation of loading, closing the breech, discharging, and expelling the empty cartridge case, is conducted whilst the barrels are kept continuously revolving. It is to be observed that whilst the locks revolve with the barrels, they have also in their line of travel a spiral reciprocating movement, that is, each lock revolves once and moves forwards and back at each revolution of the piece; the gun can be discharged with great rapidity. We have seen 400 shots fired from it in 58 seconds, which is smart practice. The shots are delivered singly in rapid succession, so that the tendency to recoil is only that produced by one shot, and this tendency is entirely overcome, and the recoil absorbed by the weight of the gun and carriage, and by a simple device attached to the trail.

A perspective view of the Fosberry-Montigny mitrailleur is given in Pl. 224, and will enable a fair comparison to be made between the two guns as far as external appearances are concerned, whilst the relative merits of their constructive details can be readily determined by comparing the following brief description with that of the Gatling gun. The question as to their relative merits in practice has already been settled by the statement of ultimate results of firing previously given. The Fosberry-Montigny mitrailleur consists of a compound barrel composed of 37 rifled tubes formed hexagonally on the outside, the whole being rigidly connected together in a cluster and encased in an outer metal cylinder. The barrels are open from muzzle to breech block, which carries 37 firing locks. To load the piece the breech block is drawn back by a lever, and a plate, which is seen in the hands of the gunner in the engraving, carrying 37 cartridges is inserted vertically in the space thus formed. The breech block is then pressed forwards, by which means the cartridges ought to be, but are not always, forced into the chambers of the barrels; in closing the breech block, the springs of the strikers are placed in tension, and are released by means of a serrated shutter which is actuated by a firing lever. By bringing this lever down rapidly the whole 37 cartridges are exploded almost simultaneously, whilst by operating it slowly single shots may be fired. It is at once apparent that with the mitrailleur it is not possible to maintain such a continuous steady fire as with the Gatling gun, nor can any reliance be placed upon the proper insertion of every cartridge in its chamber, a defect we ourselves have frequently witnessed. There are also other points of comparison between the two weapons which are too self-evident to require us to draw attention to them.

The improvements which have been made in the Gatling gun refer to the gear for rotating the piece, the method for withdrawing and replacing the locks, the arrangement for cocking the locks, the feed apparatus, and the gear for giving the gun a continuous lateral traverse. The latter arrangement has not been applied to the gun from the photograph of which the perspective view has been drawn, but only to the smallest gun, which has also been fitted with the revolving drum feed. In the old pattern gun the body was rotated by means of a large gear wheel and a pinion fixed on a crank shaft to which a handle was attached on the outside of the gun. We must here refer to Pl. 224, which shows detailed views of the gearing by which the barrels are revolved. A small worm wheel A is mounted upon the extreme rear end of the central shaft B between the diaphragm plate E and the cascable plate; a worm is formed on the transverse shaft C, which is hung in the rear part of the outer casing D. The shaft is continued outwards on the right-hand side, and carries the handle for rotating it, seen in the perspective view. It is also prolonged on the left side where it works the automatic traversing apparatus. By this arrangement sufficient room is left between the worm wheel and the outer casing to admit of the aperture F being cut in the diaphragm plate for withdrawing the locks. The arrangement for removing and inserting the locks without removing the cascable plate as was formerly done, is shown in the detailed longitudinal section of the cascable, diaphragm, and plug. It will be observed that there is an aperture cut through the cascable C, and in a line with it is a similar opening through the diaphragm plate E. Both these apertures are closed by a plug H, which is inserted from behind into the plate; the plug carries at its front end a sleeve, which has a projecting arm I, on the under side of which is cut the slot J. When the plug is in position in the gun, this slot forms a continuation of a groove cut in the rear chamber, and in which a lug, formed on the rear end of each lock, revolves. When the lock is brought into line with the plug by means of the outside handle the lug on it engages with the slot in the arm of the plug, and on the latter being withdrawn the lock follows with it. The sleeve I is connected to the body of the plug by a pin formed with the plug, and around which it is just free to revolve without being a loose fit. In withdrawing the plug it is first partially rotated so as to bring the lug K by which it is locked just opposite the slot in the aperture F. The sleeve still retains its hold of the lock to be extracted, being retained against it by a spiral spring and an elastic washer which is interposd between the plug and the sleeve. The lock and sleeve are guided into the aperture into the diaphragm plate through a tube L having a shot in its upper side, through which the sleeve of the plug passes carrying the lock with it.

We next come to the arrangement for cocking the locks, which is also illustrated. The figures show respectively a detail front view, an inner side view, and a detail top view of the cocking apparatus. The cocking was formerly effected by a stud which projected from the lock about midway of its length and which travelled up an inclined plane formed on the edge of a flat ring placed inside the breech casing; this arrangement is now superseded by the inclined spiral cocking plate N projecting on the inner side of the casing D, so that when the lock M is moved forward a lug A formed upon it is arrested by it, and the spring of the lock is thus gradually contracted and the firing pin drawn back into the lock shell. When the lug passes the end of the stationary plate N it is suddenly released, and the spring with it, causing the plunger to be forced forwards and to explode the cartridge. The plate N is stationary with the casing, whilst the lugs revolve with the lock cylinder, the plate therefore acts upon the firing pin in the several locks successively, and causes the successive discharge of the barrels as each arrives in line with it. On referring to the perspective view, it will be seen that this cocking arrangement is mounted on the framing of the gun to the right of the gun piece. In order to permit the lateral adjustment of the cocking plate, it is connected with a slide *i* which projects into a rib formed on the casing, and which has an aperture to receive the eccentric *j* on a vertical arbor *l* which is fitted into the rib as shown. By turning the arbor the eccentric will draw

the slide *i* in or out as may be desired, drawing thereby also the cocking plate N into or out of gear with the lugs on the locks. By this means gun exercise can be carried on in drill without the locks being snapped. It also forms a safeguard against accidental firing. A spring bolt is arranged on the case for locking the shaft *l*, and with it the cocking plate N either in or out of gear with the locks.

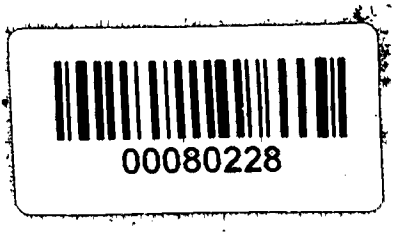
The next point claiming attention is the vertical feed drum, which consists of a metal framing of cylindrical shape and having 16 divisions or slots round its circumference and radiating from the centre. Each of these slots contains 25 cartridges placed one above the other in vertical line. A hole in the centre of the drum fits over a pin on the outer casing of the gun, in front of which is the hopper through which the cartridges are fed; the latter pass to the hopper through an aperture in the bottom of each division in the drum. On the face of the casing to the left of the hopper is a rib which projects beyond the edge of the feed-drum when in position, and the drum has a series of thumb lugs formed on its lower periphery. In firing the gun the gunner with his left hand brings one of the lugs on the bottom rim of the revolving feed-drum coincident with the rib on the hopper face, whilst with his right he turns the firing crank. The cartridges fall into the hopper from one division as soon as the gunner, and as soon as the gunner sees that one division is empty he revolves the drum one sixteenth part, bringing the next lug over the rib, and at the same time the next, the next batch of cartridges in the drum over the hopper; the feed is thus continuous until the whole 16 divisions in the drum have been emptied, when it is removed and replaced by a charged drum. On the right of the drum is a locking arrangement for keeping it in position when not actually being fired. This is a copy of Mr. Broadwell's arrangement before described.

The only portion of the mechanism of this highly ingenious gun now remaining for notice is the automatic continuous traversing motion for giving the gun lateral play against an advancing body of troops. It will be remembered that the transverse shaft which actuates the worm gear is prolonged through the rear chamber to its left; on this prolongation is cut a right and left-handed screw, which engages in a crutch attached to a vertical standard working on a bearing fixed to the framing of the gun. The standard can be raised and lowered to follow the elevation or depression of the gun, and is held in position by a set screw. As the gun is operated, the right and left-handed screw is revolved, and, working in the crutch, gives the piece a continuous lateral traverse, which can be enlarged or contracted according as may be required, thus spreading the fire over a wide range as against a body of troops, or contracting it as in a narrow pass. The cartridges used for this gun have also been improved, the result being that the shells are now capable of being re-loaded, and may be used many times over instead of being wasted after once having been discharged as they formerly were. The new arrangement is shown in Pl. 224 by a part sectional view of the cartridge shell, a side view, and an under side view of the anvil. The case A has a cavity formed in the centre of its base, into which the anvil B is inserted, and in which it is secured by having its mouth O spread open by a punch, so as to rivet the anvil to the case. The anvil has a small hole *f* formed longitudinally through it, and at the back of the anvil is a groove *s*, which crosses the end of this hole. This groove establishes a communication between the hole *f* and the interior of the cap containing the fulminate *a*. When the centre *c* of the cap is hit by the striker of the lock, the fulminate is exploded by being brought into contact with the back of the anvil, and the flash passes by the grooves *s* into the hole *f*, which communicates directly with the powder. The part G is a solid ring of solder fused into the cartridge case, which it strengthens so that the anvil remains unmoved by the blow of the striker. It further strengthens the base of the cartridge, preventing its head from bulging or splitting when heavy charges are used. The case is formed of strong brass, and with a solid head. The front of the shoulder P forms a right angle with the exterior of the case, so as to afford a good hold to enable the extractor to remove it from the chamber of the gun after it has been exploded. After it has been fired, the cap *c* is removed, and replaced with a fresh one, and in

this way the cartridges are now re-charged and discharged a great number of times. It will be seen that the Gatling gun is a very perfect piece of mechanism, and that there is nothing about it that is mysterious. If, by bad management, any clogging should take place in the feeding of the hopper in guns to which the feed-drums are not fitted, it is thrown back and the matter righted in a few seconds; if also one of the locks should become inoperative, it can be taken out and a new one inserted in a very short time. The main parts are sufficiently strong to withstand injury in use, and duplicate pieces of the smaller portions forms part of the outfit, in which is also included a supply of powder and bullets for reloading the cartridge shells. In short the gun is one of the most perfect weapons of its class at present extant, and we have only one suggestion to offer, and that is that the iron or steel screen for the protection of the man serving it, and who is seated on the trail of the gun be adopted. With the drum feed, and the traversing motion, the Gatling gun is a formidable weapon for certain purposes of warfare, and with the Broadwell screen, it is practically safe to the gunners.

For the leading dimensions and weights, details of projectiles, powder charges, and initial velocities of heavy ordnance of different classes, in use throughout the world, we refer the reader to the Tables contained in Plates 230 and 231 of the Atlas.

LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.



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on 02 July, 2018